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June 5, 2008

South Carolina Department of Health and Environmental Control  
Attention: Heather S. Preston, Director  
Water Quality Division  
Bureau of Water  
2600 Bull St  
Columbia, SC 29201-1708

Re: FERC 401 Water Quality Certification Application  
Catawba-Wateree Hydroelectric Project  
FERC Project No. 2232

Dear Ms. Preston:

Duke Energy Carolinas, LLC (Duke) operates the Catawba-Wateree Hydroelectric Project (Project), which is licensed as Federal Energy Regulatory Commission (FERC) Project No. 2232. Duke is required to obtain a new license from the FERC in order to continue operating the Project. The federal action of issuing a new license for the Project triggers the need for Duke to also obtain a water quality certification pursuant to Section 401 of the Clean Water Act.

The Application for New License was submitted to the FERC on August 29, 2006, along with a Comprehensive Relicensing Agreement (CRA), signed by 70 stakeholder organizations. The FERC has been reviewing the application and the CRA since their submittal and, as part of the relicensing process, issued a "Ready for Environmental Analysis" (REA) notice on April 7, 2008. Duke is required to submit an application for water quality certification in accordance with the requirements of the Federal Power Act within 60 days following the REA notice (June 6, 2008). The subject of this certification is the continued operation of the Project under a new FERC-issued license that is consistent with applicable sections of the Catawba-Wateree CRA.

Enclosed are one original and six copies of a complete application package for the Section 401 water quality certification of the Project. The enclosed application package is intended to provide the reasonable assurance necessary for the South Carolina Department of Health and Environmental Control to certify that, upon implementing the proposed flow and water quality modifications included in the CRA, Duke will be able to meet applicable water quality standards when operating the Project under a new FERC operating license consistent with applicable CRA provisions. Each application package includes:

- A complete and signed FERC 401 *Water Quality Certification Application* form
- A Supplemental Information Package that presents detailed explanations of:
  - The Catawba-Wateree Hydroelectric Project
  - The Catawba-Wateree Relicensing Process
  - The Catawba-Wateree Comprehensive Relicensing Agreement
  - The water quality assessment methodologies utilized by Duke
  - Plant-by-plant descriptions of proposed equipment and operational modifications and projected compliance with applicable state water quality standards
  - Streamflow mitigation calculations
  - An assessment of water quality certification criteria, including cumulative impacts
  - Supporting appendices, including the Quality Assurance Project Plan (QAPP)
  - Historical water quality data collected by Duke

If there are questions or if further information is required, please contact Mark Oakley (704-382-5778; [emoakley@duke-energy.com](mailto:emoakley@duke-energy.com)) or Tami Styer (704-382-0293; [tsstyer@duke-energy.com](mailto:tsstyer@duke-energy.com)).

Sincerely,



Steven D. Jester, Vice President  
Hydro Licensing and Lake Services  
Duke Energy Carolinas, LLC

bcc: Jeff Lineberger, Duke Energy Carolinas, LLC  
Mark Oakley, Duke Energy Carolinas, LLC  
Tami Styer, Duke Energy Carolinas, LLC  
Garry Rice, Duke Energy Carolinas, LLC  
Carol Goolsby, Duke Energy Carolinas, LLC  
George Galleher, Duke Energy Carolinas, LLC  
Scott Fletcher, Devine Tarbell and Associates  
John Whittaker, Winston and Strawn

# **CATAWBA-WATEREE HYDROELECTRIC PROJECT (FERC No. 2232)**

## **SECTION 401 WATER QUALITY CERTIFICATION APPLICATION TO THE SOUTH CAROLINA DEPARTMENT OF HEALTH AND ENVIRONMENTAL CONTROL**



**Prepared by:**  
**DUKE ENERGY CAROLINAS, LLC**  
**Charlotte, North Carolina**

**JUNE 2008**



DHEC ID: \_\_\_\_\_

**FERC 401 WATER QUALITY CERTIFICATION  
APPLICATION**

For existing Federal Energy Regulatory Commission (FERC) Permits,

**\*SEND SEVEN (7) COPIES OF THIS APPLICATION TO:**

**THE SC DEPARTMENT OF HEALTH AND ENVIRONMENTAL CONTROL**

**ATTN: HEATHER S. PRESTON, DIRECTOR**

**WATER QUALITY DIVISION**

**2600 BULL STREET**

**COLUMBIA, SC 29201**

***(PLEASE PRINT OR TYPE.)***

**1. OWNER'S NAME:**

Duke Energy Carolinas, LLC ("Duke")

**2. MAILING ADDRESS:**

Duke Energy Carolinas, LLC

c/o Mark Oakley, P.E.

526 South Church Street, P.O. Box 1006, Mail Code EC12Y

**CITY:** Charlotte **STATE:** North Carolina **ZIP CODE:** 28201-1006

**PROJECT NAME:**

Catawba-Wateree Hydroelectric Project, FERC No. 2232 (the Project) consisting of the following developments in South Carolina:

- Wylie Development
- Fishing Creek Development
- Great Falls-Dearborn Development
- Rocky Creek-Cedar Creek Development
- Wateree Development

The Federal Energy Regulatory Commission (FERC) defines the “Project” as all 11 reservoir developments in North Carolina and South Carolina. Duke utilizes this same terminology in the application, supplemental report and appendices. The federal action triggering the need to obtain this 401 Water Quality Certification is the issuance of a new operating license by the FERC for the Catawba-Wateree Project. Therefore, the subject of the certification being sought is not the Project per se, but more accurately the continued operation of the Project under a new FERC license that is consistent with the applicable sections of the Catawba-Wateree Comprehensive Relicensing Agreement (CRA). The CRA and its applicable sections are discussed in more detail in section 3.5 of the accompanying supplemental report.

**PROJECT LOCATION ADDRESS (IF DIFFERENT FROM MAILING ADDRESS ABOVE):**

- Wylie Development, 2701 Grey Rock Road, Fort Mill, SC 29708
- Fishing Creek Development, Hwy 21, 552 Catawba River Road, Great Falls, SC 29055
- Great Falls-Dearborn Development, 49 Republic Street, Great Falls, SC 29055
- Cedar Creek Development, 1 Green Road, Great Falls, SC 29055
- Rocky Creek Development, 3607 Catawba Road, Great Falls, SC 29055
- Wateree Development, 1790 Wateree Dam Road, Ridgeway, SC 29130

**3. TELEPHONE NUMBER: (WORK)**

For questions or additional information concerning any of the following developments, please contact Mark Oakley at (704) 382-5778.

- Wylie Development
- Fishing Creek Development
- Great Falls-Dearborn Development
- Cedar Creek Development
- Rocky Creek Development
- Wateree Development

**4. IF APPLICABLE:****AGENT'S NAME OR RESPONSIBLE CORPORATE OFFICIAL ADDRESS,  
PHONE NUMBER:**

Mark Oakley, P.E.

Catawba-Wateree Relicensing Project Manager

Duke Energy - Hydro Licensing

526 South Church Street, Mail Code EC12Y

Charlotte, NC 28202

(704) 382-5778

E-mail: emoakley@duke-energy.com

**5. LOCATION PROJECT (PROVIDE A MAP, INCLUDING A COPY OF USGS  
TOPOGRAPHIC MAP OR AERIAL PHOTOGRAPHY WITH SCALE):****COUNTY:** \_\_\_\_\_ **NEAREST TOWN:** \_\_\_\_\_**SPECIFIC LOCATION (INCLUDE ROAD NUMBERS, LANDMARKS, ETC.)****Table 1. Location of Project.**

<b>Development</b>	<b>County (Powerhouse Location)</b>	<b>Nearest Town</b>	<b>Landmark (Distances are approximate)</b>
Wylie	York	Fort Mill	3.0 miles north of the intersection of NC State Route 161 and US Interstate 77
Fishing Creek	Chester	Great Falls	0.25 mile northeast of the intersection of US Hwy 21 and SC State Route 97
Great Falls- Dearborn	Chester	Great Falls	1.5 miles northeast of the intersection of US Hwy 21/SC State Route 200 and Brooklyn Rd./SC State Route S-12-141
Rocky Creek	Chester	Great Falls	3.25 miles northeast of the intersection of SC State Route 200 and Catawba Rd./SC State Route S-20-20.
Cedar Creek	Chester	Great Falls	3.75 miles southwest of the intersection of SC Secondary Route 20/Green Road and SC State Route 97/Cedar Creek Rd
Wateree	Kershaw	Ridgeway	1.0 mile east of the intersection of SC State Route S-28-37/Wateree Dam Rd. and SC State Route S-28-843/Buck Hill Rd

See Supplemental Information Package Sections 5.1 through 5.6 for location and topographic maps.

**6. IMPACTED STREAM/RIVER:** Catawba-Wateree **RIVER BASIN:** Catawba-Wateree  
**CURRENT DEPARTMENT OF HEALTH AND ENVIRONMENTAL CONTROL (DHEC) CLASSIFICATION:** Fresh Waters (FW) - Entire Catawba-Wateree Tributary to the Santee River

**Table 2. Designated uses and water quality assessments for reservoirs and river reaches in the Catawba River Basin.<sup>1</sup>**

<b>Reservoir/River Reach</b>	<b>Designated Use Classifications<sup>2</sup> Assigned by the SCDHEC</b>	<b>Mean Depth (ft)</b>	<b>Full Pond Surface Area (ac)</b>
Lake Wylie (South Carolina)	FW	22.9	12,177
Fishing Creek Reservoir	FW	23.6	3,431
Great Falls Reservoir	FW	8.2	353
Cedar Creek Reservoir	FW	28.8	748
Lake Wateree	FW	22.6	13,025
Wateree River: Downstream of Lake Wateree at Highway 1 bridge	FW	NA	NA

<sup>1</sup> Classifications and assessments are from the Catawba Basin Watershed Water Quality Assessment, February 2005 (SCDHEC 2000a). Sites rated less than fully supporting are classified as impaired (SCDHEC 2000a). Sources of impairments are listed in parentheses.

<sup>2</sup> Definitions of designated use classifications:

**FW** (South Carolina): Fresh waters suitable for propagation of aquatic life, primary and secondary recreational contact, and as drinking water source.

**7. (a) IS THE PROJECT LOCATED WITHIN A DHEC OFFICE OF OCEAN AND COASTAL RESOURCE MANAGEMENT (OCRM) CRITICAL AREA?**

NO. All Projects are outside and upstream of the OCRM Critical Area

**(b) IF THE PROJECT IS LOCATED WITHIN A COASTAL COUNTY, HOW WILL THE PROPOSED IMPACTS AFFECT THE COASTAL ZONE MANAGEMENT PLAN (CZMP)?** NA

**8. (a) ARE ADDITIONAL PERMIT REQUESTS EXPECTED FOR THIS PROPERTY IN THE FUTURE?**

NO.

**IF YES, DESCRIBE ANTICIPATED WORK:** NA

**9. (a) ESTIMATED TOTAL NUMBERS OF ACRES IN PROJECT:**

Refer to Item 11, Table 6 of this application.

**10. PROVIDE AN APPROPRIATE ENVIRONMENTAL DOCUMENT.**

**THE DOCUMENT SHOULD ADDRESS:**

**(a) DATA SHOWING THAT A 7Q10 MINIMUM FLOW WILL BE PROVIDED**

In lieu of 7Q10 flows, detailed resource assessments were conducted. The resulting aquatic flow needs were balanced with other water use needs in order to be sustainable into the future while meeting resource agency protection, mitigation and enhancement goals. At some locations, the hydroelectric station releases directly into the downstream reservoir and no riverine environment exists. At some locations, aquatic resource improvements were achieved but do not fully meet resource agency goals. Mitigation information is provided in Section 6 of the Accompanying Supplemental Report.

For each development, operational changes and/or mechanical installations and/or upgrades are proposed to provide minimum flows in accordance with the Flow and Water Quality Implementation Plan (FWQIP) contained in the Catawba-Wateree Comprehensive Relicensing Agreement (CRA). Stream flow records on the Catawba and Wateree Rivers reflect only the regulated operations and reservoir management of the hydroelectric stations, including extreme low flow conditions when the hydro stations release no flow between peak electric demand periods. Therefore, the 7Q10 statistics has little relevance in establishing a natural flow threshold level.

**(b) A COST BENEFIT ANALYSIS OF THE PROJECT SHOWING WHY THE PROJECT IS STILL NECESSARY**

The continued operation of the Catawba-Wataree Project has no practical alternative. Fourteen counties and more than 30 municipalities depend now and in the future on the following critical benefits provided by the Project that cannot be practically replaced:

- Energy: In addition to currently providing the energy to power 116,000 homes (on an average yearly basis) and water to support over 8,100 megawatts (MW) of fossil and nuclear-fueled power plants (44 percent of Duke's North Carolina and South Carolina generating fleet), the Catawba-Wataree River is a critical component in meeting future electric supply needs. Duke's system demand for electricity in North Carolina and South Carolina is expected to more than double over the next 50 years and a substantial portion of that new generation capacity is expected to rely on the Catawba-Wataree River.
- Drinking Water: The Catawba-Wataree River provides a reliable drinking water supply for over 1.3 million people. Future public water supply needs are projected to increase over 200 percent in the next 50 years.
- Jobs: The Catawba-Wataree River also provides a reliable water supply that is vital to the operations of several large industrial facilities, a key component to the economic vitality of the region.

From an economic cost-benefit perspective, the benefits of the Project as a resource for both electric capacity and energy can be expressed in terms of avoided costs. For the purposes of this application, avoided costs are energy, capacity, and severance fees that would be incurred if Duke's certification request was denied. Certification denial would result in a loss of the FERC license. A Project takeover by another applicant would impact Duke, its customers, and its investors in many ways. Since the Project is a component of a power system mix that consists of multiple types of generation with various fuel sources, impacts extend beyond the value of the firm capacity and energy contribution from the

Project itself. The full extent of actual severance damages would be dependent upon the details of the system separation, assets involved, the characteristics of the replacement power source, and the compensation mechanism used to reimburse Duke for the system value lost due to removing the power and reliability provided by the Project. Since many of these details are uncertain, some simplification and assumptions must be made in preparing an estimate. For purposes of this application, the severance damage calculation has been limited to estimates of the value lost and additional costs incurred by severing the Project from the system and by replacing it with an alternative hydro generation resource. Severance damages are estimated to be \$1,076,083,338 in 2006 dollars.

If a certification or license were not granted, alternative power would be obtained from other resources within Duke's generation system or from purchased power. Under normal conditions, either of these resources should be capable of providing the necessary replacement energy, although at a higher system price and with higher air and water emission implications.

Duke would incur various costs in replacing the power output from the licensed Project with alternative generation and/or purchased power. Actual replacement costs would depend on many factors including the replacement source, location, fuel type, and availability. For purposes of a severance damage calculation, the alternative has been assumed to be replacement with a storage hydro project that is connected to the transmission grid and is being compensated at current SCHEDULE PP-H (NC) 15-year fixed rates. The Catawba-Wateree Project consists of 13 hydroelectric stations located on 11 reservoirs. The generation characteristics of each hydroelectric station in the Project were used to define the generation profiles for the alternative resources to duplicate a replacement in kind. The stations located on common impoundments (Great Falls-Dearborn and Rocky Creek-Cedar Creek) are treated as single generation and transmission entities due to the shared water source and some common equipment and cost components.

The methodology used to estimate replacement costs uses two cost components: energy cost and capacity cost. The SCHEDULE PP-H (NC) rate structure is designed to provide

compensation for both of these components on a generation profile basis. Historical generation records, profiles for the stations in the Project, and results of recent modifications have been combined to calculate a current year value of Project power estimate of \$86,427,034 in 2006 dollars. The current average annual cost of power produced by the Project is \$45,321,369 as shown in the calculations within Section H3.1 of Exhibit H and Section D4.0 of the Application for New License, filed with FERC on August 26, 2006. This figure contains an annual cost component for capital charges that would be recovered within the net investment recovery in the event of Project takeover. The annual avoided operating costs are \$22,324,345 with the cost of capital removed. The difference between the \$86,427,034 value of power estimate and the \$22,324,345 avoided operating costs is \$64,102,688. This is the current annual cost of replacing Project generation.

Applying appropriate inflation and discount rates to the current annual cost of replacing Project generation over a reasonable license period could be used to estimate the generation component of severance damages. Generation severance damage cost for the period 2006–2045 is estimated to be \$1,040,088,071.

In addition to costs incurred from generation severance, Duke would incur costs from transmission facility severance damages. These are the values of the equipment lost, the costs of certain system modifications that would be required to maintain reliable and functional service, and the costs that would be incurred in providing transmission system interconnection for a new owner. Transmission system interconnection cost represents those efforts necessary to establish a terminal position complete with all required protective devices, switches, bus, wiring, support structures, relaying, controls, metering, and telemetry to reliably accommodate interconnection and to monitor energy delivered to the transmission system.

The Catawba-Wateree Project transmission severance damages are estimated to be \$26,110,232 for separation expenses and \$9,885,035 for interconnection costs, yielding a total transmission system severance damage estimate of \$35,995,267 in 2006 dollars.

Detailed information regarding these calculations can be found in the Application for New License Exhibit D: Report on cost and financing and Exhibit H: Report on Supplemental Information.

**(c) DESCRIPTION OF LENGTH OF BYPASS REACH (IF ANY) AND MEASURES TO PROVIDE FLOW TO THE REACH IN LOW FLOW CONDITIONS.**

Due to the configuration of most of the dams in the South Carolina Project Area, the only bypassed reaches in South Carolina associated with the Project are located below Great Falls-Dearborn Reservoir and Lake Wateree. Flows that are present within both the long (2.25 mi.) and short (0.75 mi.) bypassed reaches of Great Falls and the bypassed reach of Wateree (0.34 mi.) are provided by the Licensee, and from dam seepage and accretion. Duke has agreed to install flow release structures at the Great Falls Development that will provide a year-round minimum flow of 450 cfs (850 cfs from February 15-May 15) to the long bypassed reach and 100 cfs to the short bypassed reach.

The Low Inflow Protocol (LIP) provides trigger points and procedures for how the Catawba-Wateree Project will be operated by Duke, as well as water withdrawal reduction measures and goals for other water users during periods of low inflow (i.e., periods when there is not enough water flowing into the Project reservoirs to meet the normal water demands while maintaining Remaining Usable Storage in the reservoir system at or above a seasonal target level). A component of the LIP is critical flows. Critical flows are the minimum flow releases from the hydro developments that may be necessary to:

1. Prevent long-term or irreversible damage to aquatic communities consistent with the resource management goals and objectives for the affected stream reaches;
2. Provide some basic level of operability for Large Water Intakes located on the affected stream reaches; and
3. Provide some basic level of water quality maintenance in the affected stream reaches.

**(d) MEASURES PLANNED OR TAKEN TO MAINTAIN DOWNSTREAM WATER QUALITY SUCH AS ADEQUATE DISSOLVED OXYGEN.**

It is important to note that there are currently no water quality requirements for the Catawba-Wateree Project. Because the Project was originally licensed in 1958, prior to the implementation of the federal Clean Water Act, the Project has never been required to obtain a Section 401 Water Quality Certification. Consequently, there are no water quality provisions in the current (soon to expire) license. However, Duke has monitored water quality within the Project and has taken voluntary measures to allow the enhancement of water quality (i.e., dissolved oxygen) during major equipment replacement outages.

Measures Already Taken

Because historical dissolved oxygen (DO) conditions from many of the Catawba-Wateree Project releases were at times lower than the DO standard established by North and South Carolina, Duke, as part of the station upgrades and hydro runner replacements, evaluated and installed various turbine venting modifications at some stations (summarized below) to boost DO concentrations in the downstream reaches.

**Table 3. Locations of descriptions of current measures for enhancing dissolved oxygen for the Catawba-Wateree Hydroelectric Developments in South Carolina.**

<b>Development</b>	<b>Existing Turbine Venting</b>
Wylie	Enhanced Vacuum Breaker (Unit 1) Hub Venting Runners (Units 2 & 3) Original Vacuum Breaker (Unit 4)
Fishing Creek	Hollow Stay Vanes (Units 1 & 2) Hub Venting Runner (Unit 3) Original Vacuum Breaker (Units 4 & 5)
Great Falls* – Dearborn	Hollow Stay Vanes (Dearborn Units 1-3)
Rocky Creek* – Cedar Creek	Enhanced Vacuum Breaker (Unit 1) Hub Venting Runner (Units 2 & 3)
Wateree	Auto Venting Runner (Units 1 & 3) Enhanced Vacuum Breaker (Units 2, 4 & 5)

\* All Great Falls and Rocky Creek Units are horizontal shaft turbine units and no conventional aeration is possible

Turbine venting utilizes existing low pressure areas within the scroll case, turbine, or draft tube which, if vented to the atmosphere, would draw air into the flowing water. Vacuum breakers, i.e. small air valves opened routinely to equalize the air pressures at the beginning and end of a generation cycle, allow minimal air flow into the hub or cone of a Francis turbine. Hub venting enhances the air flow by replacing the vacuum breakers with either

more and/or larger air induction ports which are opened during electric generation to allow air to flow into the low pressure area at the hub or cone of the turbine. Stay vane venting (stay vanes are metal, sometimes hollow, plates that direct water into the turbine) modifications allow air to flow from specially constructed air induction ports into the hollow portion of the plates and into the water at the low pressure, trailing edge of the stay vanes. Auto venting is a relatively recent innovation which, in addition to utilizing other low pressure areas for air induction, employs uniquely constructed, hollow turbine blades for air introduction.

Please refer to Table 4 for additional measures proposed by Duke to meet minimum flow release and/or DO requirements. This is also Appendix L of the CRA - Flow and Water Quality Implementation Plan.

Additional information is also available in the following sections of the CRA:

- Section 4.6: South Carolina Flow Mitigation Package
- Section 6.0: Low Inflow Protocol Agreements
- Appendix A-Section A-3: Low Inflow Protocol Article
- Appendix C: Low Inflow Protocol (LIP) for the Catawba-Wateree Project
- Appendix A-Section 2.0: Minimum Flows, Wylie High Inflow Protocol, Flows Supporting Public Water Supply and Industrial Processes, and Flow and Water Quality Implementation Plan

#### Quality Assurance Project Plan (QAPP)

Appendix A of the accompanying Supplemental Information Package presents a detailed description of the QAPP that is proposed for the Catawba-Wateree Project.

**Table 4. Appendix L of the Catawba-Wateree CRA.****APPENDIX L: FLOW AND WATER QUALITY IMPLEMENTATION PLAN (FWQIP)**

The Flow and Water Quality Implementation Plan (FWQIP) table that follows presents an outline of:

- A site-specific list of measures that the Licensee will take for providing aquatic flows, recreation flows and for meeting the applicable water quality standards;
- A schedule for when these measures will be implemented; and
- A schedule for any interim measures that will be taken to address flow releases or dissolved oxygen (DO) improvements prior to completing the necessary physical modifications to the Project.

Dates are subject to change due to items beyond the Licensee's control such as materials availability, manufacturing capacity, transportation schedules and installation contractor availability. The Licensee will however make every reasonable effort in its planning and implementation to minimize the chance of delays in this schedule.

<b>Location</b>	<b>Timeframe for Operational Change to Implement Flows and/or Enhance DO where No Physical Modifications are Anticipated</b> (Note 7)	<b>Physical Modifications Proposed to Meet Flow and/or DO Requirements</b> (Note 8)	<b>Timeframe for Completing Physical Modifications and Implementing Flows and/or DO Enhancements</b> (Note 1)	<b>Interim Measures for Providing Aquatic Flow and/or DO Enhancement until Physical Modifications are Complete</b> (Notes 3, 7)
<b>Bridgewater Development</b> (Notes 2, 4, 6)				
Catawba Dam	NA	New flow valve with aerating capability	15 months following FERC approval of FWQIP to be coordinated with the Bridgewater Dam Upgrade Project	None
Linville Dam	NA	New Powerhouse with aerating capability on all units or flow valve system (Note 2)	2010 (subject to schedule and FERC approvals related to Bridgewater Dam Upgrade Project).	None

<b>Location</b>	<b>Timeframe for Operational Change to Implement Flows and/or Enhance DO where No Physical Modifications are Anticipated</b> (Note 7)	<b>Physical Modifications Proposed to Meet Flow and/or DO Requirements</b> (Note 8)	<b>Timeframe for Completing Physical Modifications and Implementing Flows and/or DO Enhancements</b> (Note 1)	<b>Interim Measures for Providing Aquatic Flow and/or DO Enhancement until Physical Modifications are Complete</b> (Notes 3, 7)
<b>Rhodhiss Development</b>				
Rhodhiss Dam & Powerhouse	NA	New aerating runner on Unit 3	48 months following FERC approval of the FWQIP	Beginning within 60 days after the date of closure of the New License, when DO is below state standards, operate units with existing stay vanes and vacuum breaker aeration (two units) on a first-on, last-off hierarchy whenever the station is being operated for flow release, reservoir level control, or generation.
<b>Oxford Development</b>				
Oxford Dam	NA	- New flow valve with aerating capability - New aerating runner on one existing unit	-19 months following FERC approval of FWQIP - 36 months following FERC approval of FWQIP	Beginning within 60 days following the date of closure of the New License, raise a flood gate during periods of no generation to release and aerate the Minimum Continuous Flow.
<b>Lookout Shoals Development</b>				
Lookout Shoals Powerhouse	Beginning within 60 days following the date of closure of the New License, operate existing vacuum breakers (three units) as needed to meet state standards for DO while monitoring Oxford DO carry-over benefits. If necessary, add aerating capacity to auxiliary units. Operate existing large or auxiliary units as needed to provide minimum flow.	NA	NA	NA

<b>Location</b>	<b>Timeframe for Operational Change to Implement Flows and/or Enhance DO where No Physical Modifications are Anticipated</b> (Note 7)	<b>Physical Modifications Proposed to Meet Flow and/or DO Requirements</b> (Note 8)	<b>Timeframe for Completing Physical Modifications and Implementing Flows and/or DO Enhancements</b> (Note 1)	<b>Interim Measures for Providing Aquatic Flow and/or DO Enhancement until Physical Modifications are Complete</b> (Notes 3, 7)
<b>Cowans Ford Development</b>				
Cowans Ford Powerhouse & Dam	Beginning within 60 days following the date of closure of the New License, operate existing units as needed. No flow or DO enhancements are needed.	NA	NA	NA
<b>Mountain Island Development (Note 5)</b>				
Mountain Island Powerhouse & Dam	Beginning within 60 days following the date of closure of the New License, operate existing stay vane aeration units as needed. No flow or DO enhancements are needed.	NA	NA	NA
<b>Wylie Development</b>				
Wylie Powerhouse	NA	Replace one existing hydro unit with a smaller unit with aerating capability	30 months following FERC approval of FWQIP	Beginning within 60 days following the date of closure of the New License, pulse an existing unit 1 hr on, 2 hrs off during periods when at least 1 unit is not running continuously. When DO is below state standards, operate two existing units with hub-venting capability on a first-on, last-off hierarchy whenever the station is being operated for flow release, reservoir level control or generation.

<b>Location</b>	<b>Timeframe for Operational Change to Implement Flows and/or Enhance DO where No Physical Modifications are Anticipated</b> (Note 7)	<b>Physical Modifications Proposed to Meet Flow and/or DO Requirements</b> (Note 8)	<b>Timeframe for Completing Physical Modifications and Implementing Flows and/or DO Enhancements</b> (Note 1)	<b>Interim Measures for Providing Aquatic Flow and/or DO Enhancement until Physical Modifications are Complete</b> (Notes 3, 7)
<b>Fishing Creek Development</b>				
Fishing Creek Powerhouse & Dam	Beginning within 60 days following the date of closure of the New License, operate existing stay vanes (two units) and hub venting (one unit) as needed to meet state standards for DO.	NA	NA	NA
<b>Great Falls – Dearborn Development</b>				
Great Falls Diversion Dam (Long Bypass)	NA	Combination notches/gates and/ or bladder dam	21 months following FERC approval of FWQIP	None
Great Falls Headworks (Short Bypass)	NA	Combination existing trash gate and/or bladder dam	21 months following FERC approval of FWQIP	Beginning within 60 days following the date of closure of the New License, provide as close as possible to the prescribed aquatic flows via the existing trash gate.
Dearborn Powerhouse	Beginning within 60 days following the date of closure of the New License, operate existing vacuum breakers (three units) as needed to meet state standards for DO while monitoring Fishing Creek DO carry-over benefits.	NA	NA	NA

<b>Location</b>	<b>Timeframe for Operational Change to Implement Flows and/or Enhance DO where No Physical Modifications are Anticipated</b> (Note 7)	<b>Physical Modifications Proposed to Meet Flow and/or DO Requirements</b> (Note 8)	<b>Timeframe for Completing Physical Modifications and Implementing Flows and/or DO Enhancements</b> (Note 1)	<b>Interim Measures for Providing Aquatic Flow and/or DO Enhancement until Physical Modifications are Complete</b> (Notes 3, 7)
<b>Rocky Creek – Cedar Creek Development</b>				
Cedar Creek Powerhouse & Dam	Beginning within 60 days following the date of closure of the New License, operate existing hub venting capability (three units) as needed to meet state standards for DO while monitoring the benefit of continuous flows through Great Falls Bypassed Reaches.	NA	NA	NA
<b>Wateree Development</b>				
Wateree Powerhouse	Beginning within 60 days following the date of closure of the New License, operate existing hydro units as necessary to provide downstream flow requirement. Also operate existing units with auto-venting capability as needed to meet state standards for DO.	Replace one existing hydro unit with a smaller unit with aerating capability	30 months following FERC approval of FWQIP	Beginning within 60 days following the date of closure of the New License, approximate minimum continuous flows by (1) pulsing an existing unit 1 hr on, 2 hrs off from May 16 thru Feb 14 during periods when at least 1 unit is not running continuously and (2) running an existing hydro unit continuously from Feb 15 thru May 15. When DO is below state standards, operate existing units with auto-venting capability on a first-on, last off hierarchy whenever the station is being operated for flow release, reservoir level control or generation.

**Notes:**

1. The FWQIP will be filed with NCDWQ and SCDHEC during the 401 Water Quality Certification processes as the recommended flow and water quality implementation plan. NCDWQ and SCDHEC will take the recommended FWQIP under advisement and will approve and/or modify the FWQIP in the 401

Water Quality Certification. The FERC must then approve the FWQIP before the Licensee can begin construction at any location, except for Bridgewater (see Note 2 below). Also, since the FERC approval order for the FWQIP can substantially modify the Licensee's proposed FWQIP, the Licensee will not contract for the manufacture or installation of large capital cost items until FERC approval is obtained.

2. At Bridgewater, retirement of the existing powerhouse and its replacement with a new powerhouse (or flow valve system) is being performed as part of the ongoing Bridgewater Dam Upgrade Project, and FERC approval will be obtained in conjunction with that project. The Licensee's final decision on replacing the existing powerhouse with a new powerhouse or a flow valve system may not be made until after the application for a New License is filed with the FERC. Regardless of the alternative chosen, the new facilities will be designed to provide the prescribed flows and meet the applicable state water quality standards.
3. The interim measures will be implemented as indicated except when the Licensee is operating under the Low Inflow Protocol (LIP) or the Maintenance and Emergency Protocol (MEP).
4. Paddy Creek Bypassed Reach: No flow releases are proposed in the Paddy Creek Bypassed Reach. Parties to this Agreement agree to recommend the mitigation package as presented in Section 4.0 of this Agreement in lieu of flow releases into the Paddy Creek Bypassed Reach for consideration by the NCDWQ and the FERC in the 401 Water Quality Certification process and the license issuance process, respectively.
5. Mountain Island Bypassed Reach: No flow releases are proposed in the Mountain Island Bypassed Reach. Parties to this Agreement agree to recommend the mitigation package as presented in Section 4.0 of this Agreement in lieu of flow releases into the Mountain Island Bypassed Reach for consideration by the NCDWQ and the FERC in the 401 Water Quality Certification process and the license issuance process, respectively.
6. The Licensee will consult with the resource agencies during further development of the FWQIP to discuss options for reducing resource impacts during any periods of reduced flow associated with the Bridgewater Dam Upgrade Project.
7. For the purpose of this Appendix L only, "date of closure for the New License" will mean the first day following the issuance of the New License and the closure or all rehearing and administrative challenge periods related to water quantity, including Project flow releases and reservoir levels, and water quality.
8. If a state water quality agency requires equipment modifications in addition to those listed in this Appendix L to assure compliance with applicable state water quality standards for Dissolved Oxygen (DO), the fact that such modifications are not currently specified in this Appendix L does not render those modifications inconsistent with this Agreement pursuant to Section 21.0. However, any equipment modifications necessary to assure compliance with any other applicable state water quality standard or any other regulatory requirements to provide flow releases, and/or reservoir levels other than the flow releases and reservoir levels specified in this Agreement may be inconsistent with this Agreement and may be subject to review pursuant to the provisions of Section 21.0.

**11. WHAT IS THE SIZE OF THE WATERSHED?****Table 5. Catawba-Wateree River basin drainage area.**

<b>Impoundment</b>	<b>Individual Drainage Basin (sq. mi.)</b>	<b>Cumulative Drainage Area (sq. mi.)</b>
Lake Wylie	1,160	3,020
Fishing Creek Reservoir	790	3,810
Great Falls-Dearborn Reservoir	290	4,100
Cedar Creek Reservoir	260	4,360
Lake Wateree	4,750	4,750
Total Drainage Area Within South Carolina		1,730

**WHAT IS THE FULL-POND SURFACE AREA?****Table 6. Catawba-Wateree impoundment surface areas.**

<b>Impoundment</b>	<b>Full-Pond Surface Area (ac)</b>
Lake Wylie	12,177
Fishing Creek	3,431
Great Falls-Dearborn	353
Cedar Creek	748
Lake Wateree	13,025
Total Impoundment Surface Areas	<b>29,734</b>

- 12. YOU ARE REQUIRED TO CONTACT THE US FISH AND WILDLIFE SERVICE AND/OR NATIONAL MARINE FISHERIES SERVICE REGARDING THE PRESENCE OF ANY FEDERALLY LISTED OR PROPOSED FOR LISTING ENDANGERED OR THREATENED SPECIES OR CRITICAL HABITAT IN THE PERMIT AREA THAT MAY BE AFFECTED BY THE PROPOSED PROJECT. DATE CONTACTED:**

Letter from Roger L. Banks (USFWS - Field Supervisor) and David H. Rackley (NOAA Fisheries - Charleston Area Office Chief), received on May 30, 2003, in association with Project ESA Section 7 consultation request (February 7, 2003) and subsequent letters/discussions with the USFWS throughout the relicensing stakeholder process. This letter served as a combined response from both the Asheville, NC and Charleston, SC FWS field offices and addressed Section 7 concerns in both states.

- 13. YOU ARE REQUIRED TO CONTACT THE STATE HISTORIC PRESERVATION OFFICER (SHPO) REGARDING THE PRESENCE OF HISTORIC PROPERTIES IN THE PERMIT AREA WHICH MAY BE AFFECTED BY THE PROPOSED PROJECT. DATE CONTACTED:**

Letter from Jen R. Huff (Duke Energy - Hydro Licensing and Compliance), sent November 19, 2004 to Richard Sidebottom (South Carolina Department of Archives and History - State Historic Preservation Officer) regarding the Catawba-Wateree Hydroelectric Project Relicensing, Cultural Studies Draft Study Report, and soliciting comments and questions. Additional letters/discussions with the SHPO throughout the relicensing stakeholder process. An e-mail from Chad Long of the SC State Historic Preservation Office dated June 27, 2006, documents the acceptability of the Historic Properties Management Plan associated with the New License.

- 14. THE FOLLOWING ITEMS SHOULD BE INCLUDED WITH THIS APPLICATION IF PROPOSED ACTIVITY INVOLVES THE DISCHARGE OF EXCAVATED OF FILL MATERIAL INTO WETLANDS:** Not Applicable
- (a) WETLAND DELINEATION MAP SHOWING ALL WETLANDS, STREAMS, LAKES, AND PONDS ON THE PROPERTY (FOR NATIONWIDE PERMIT**

**NUMBERS 14, 18, 21, 26, 29, AND 38). ALL STREAM (INTERMITTENT AND PERMANENT) ON THE PROPERTY MUST BE SHOWN ON THE MAP. MAP SCALES SHOULD BE 1 INCH EQUALS 50 FEET OR 1 INCH EQUALS 100 FEET OF THEIR EQUIVALENT.**

**(b) IF AVAILABLE, REPRESENTATIVE PHOTOGRAPH OF WETLANDS TO BE IMPACTED BY PROJECT.**

**(c) IF DELINEATION WAS PERFORMED BY A CONSULTANT, INCLUDE ALL DATA SHEETS RELEVANT TO THE PLACEMENT OF THE DELINEATION LINE.**

**(d) ATTACH A COPY OF THE STORMWATER MANAGEMENT PLAN IF REQUIRED.**

**(e) WHAT IS LAND USE OF SURROUNDING PROPERTY?**

**(f) IF APPLICABLE, WHAT IS PROPOSED METHOD OF SEWAGE DISPOSAL?**

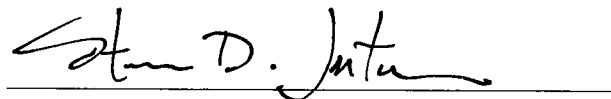
- 15. PUBLIC NOTICE IS REQUIRED FOR ALL FERC PROJECTS. PLEASE NOTE THAT THE APPLICANT IS REQUIRED TO REIMBURSE THE DEPARTMENT OF HEALTH AND ENVIRONMENTAL CONTROL FOR THE COSTS ASSOCIATED WITH THE PLACEMENT OF THE PUBLIC NOTICE. REFERENCE DHEC R.61-101.**

**SIGNED AND DATED AGENT AUTHORIZATION LETTER, IF APPLICABLE.**

**NOTE: WETLANDS OR WATERS OF THE US MAY NOT BE IMPACTED PRIOR TO:**

- 1. ISSUANCE OF A SECTION 404 CORPS OF ENGINEERS PERMIT,**
- 2. EITHER THE ISSUANCE OR WAIVER OF A 401 DIVISION OF WATER QUALITY CERTIFICATION, AND**
- 3. (IN THE EIGHT COASTAL COUNTIES ONLY), A LETTER FROM THE SOUTH CAROLINA OFFICE OF COASTAL RESOURCE MANAGEMENT STATING THE PROPOSED ACTIVITY IS CONSISTENT WITH THE SOUTH CAROLINA COASTAL ZONE MANAGEMENT PLAN,**

**OWNER'S/AGENT'S SIGNATURE**



Steven D. Jester, Vice President  
Hydro Licensing and Lake Services  
Duke Energy Carolinas, LLC



**DATE**

**(AGENT'S SIGNATURE VALID ONLY IF AUTHORIZATION LETTER FROM THE OWNER IS PROVIDED).**

**SOUTH CAROLINA 401 WATER QUALITY CERTIFICATION  
SUPPLEMENTAL INFORMATION PACKAGE**

**CATAWBA-WATEREE HYDROELECTRIC PROJECT**  
**(FERC No. 2232)**  
**SOUTH CAROLINA 401 WATER QUALITY CERTIFICATION APPLICATION**  
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## Section 1

# Introduction

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Duke Energy Carolinas, LLC (Duke) operates the Catawba-Wateree Hydroelectric Project (Project), which is licensed as Federal Energy Regulatory Commission (FERC) Project No. 2232. Duke is required to obtain a new license (New License) to continue operating the Project. The federal action of issuing a New License for the Project triggers the need for Duke to obtain a water quality certification pursuant to Section 401 of the federal Clean Water Act. The Application for New License was submitted to the FERC on August 29, 2006, along with a Comprehensive Relicensing Agreement (CRA), signed by 70 stakeholder organizations and individuals. The FERC has been reviewing the application and CRA since its submittal and, as part of the process, issued a “Ready for Environmental Analysis” (REA) on April 7, 2008. The REA requires that Duke submit an application for water quality certification in accordance with the requirements of the Federal Power Act within 60 days following the REA notice (June 6, 2008).

By filing this application, Duke is seeking to obtain state certification in accordance with the Clean Water Act Section 401. The subject of this certification is the continued operation of the Project under a FERC-issued New License that is consistent with applicable sections of the Catawba-Wateree CRA. Applicable sections are listed in Section 3.5 of this document. This application is intended to provide the basis to certify that the operations of the Project under the New License are consistent with applicable CRA provisions and provide reasonable assurance that Duke will be able to meet applicable water quality standards in accordance with Section 401 of the Clean Water Act.

## Section 2

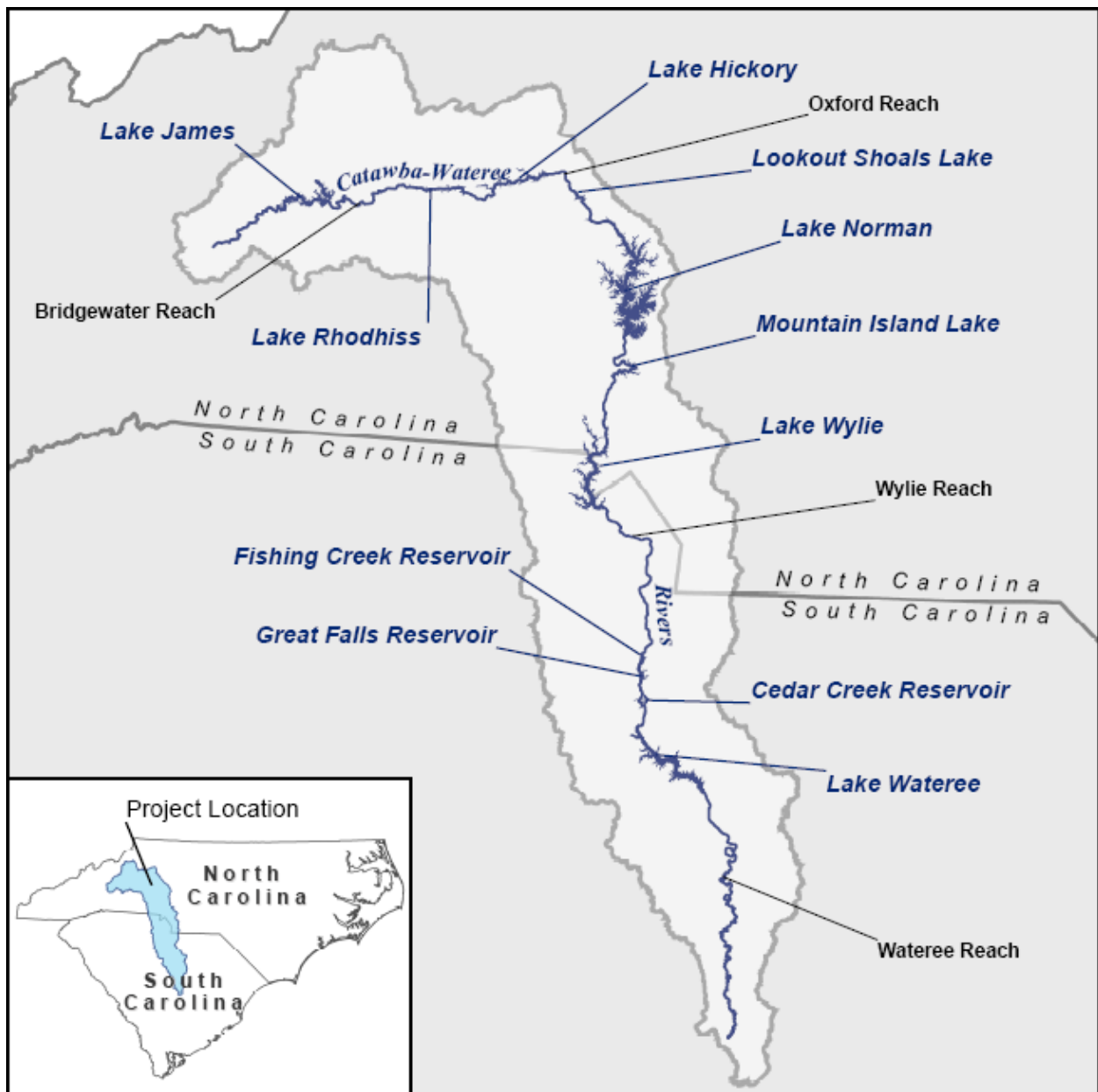
# Catawba-Wateree Project Description

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The Catawba River begins in western North Carolina and flows easterly and southerly into South Carolina, where it joins Big Wateree Creek to form the Wateree River. The Project is made up of 13 hydroelectric stations and 11 reservoirs on the Catawba and Wateree rivers. Reservoirs along the Project include Lake James, Lake Rhodhiss, Lake Hickory, Lookout Shoals Lake, Lake Norman, and Mountain Island Lake in North Carolina; and Lake Wylie, Fishing Creek Reservoir, Great Falls Reservoir, Cedar Creek Reservoir, and Lake Wateree in South Carolina (see Figure 1). Construction of the Project's developments began in the early 1900s, with the final development (Cowans Ford) completed in 1963.

The Project spans over 225 river miles, has a total drainage area of 4,750 square miles, and encompasses approximately 1,795 miles of reservoir and island shoreline within nine counties in North Carolina and five counties in South Carolina. The Project does not occupy any federal or tribal lands. Table 1 below lists the physical aspects of each development.

**FIGURE 1**  
**CATAWBA-WATEREE PROJECT (FERC NO. 2232)**



**TABLE 1**  
**CATAWBA-WATEREE PROJECT – PHYSICAL DESCRIPTION OF EACH DEVELOPMENT**

<b>Reservoir</b>	<b>Full Pond Contour (ft above MSL)</b>	<b>Lake Surface Area (ac)</b>	<b>PBL Full Pond Shoreline Miles*</b>	<b>SMP Shoreline Miles**</b>	<b>Island Full Pond Shoreline Miles</b>	<b>Island Acreage (Private islands not included)</b>	<b>Volume (ac-ft)</b>	<b>Mean Depth (ft)</b>	<b>County/State</b>
James	1200.0	6754	153.0	149.0	4.3	91	275,300	44.3	Burke/McDowell, NC
Rhodhiss	995.1	2724	106.8	95.9	0.6	2	46,500	20.6	Burke/Caldwell, NC
Hickory	935.0	4072	115.7	109.8	0.0	0	103,300	31.1	Alexander/Burke/ Caldwell/Catawba, NC
Lookout Shoals	838.1	1155	35.2	33.1	3.8	27	25,000	24.6	Alexander/Catawba/ Iredell, NC
Norman	760.0	32,339	603.1	562.3	18.8	175	1,093,600	33.5	Mecklenburg/ Iredell/Catawba/ Lincoln, NC
Mountain Island	647.5	3117	96.5	94.3	3.3	47	57,300	17.7	Mecklenburg/ Lincoln/Gaston, NC
Wylie	569.4	12,177	348.5	340.3	3.7	35	229,200	22.9	Gaston/ Mecklenburg, NC York, SC
Fishing Creek	417.2	3431	85.1	90.4	5.1	62	48,800	23.6	Lancaster/Chester, SC
Great Falls	355.8	353	13.1	13.2	4.2	800	1700	8.2	Chester/Lancaster/ Fairfield, SC
Cedar Creek	284.4	748	23.2	22.3	4.9	124	7,900	28.8	Chester/Lancaster/ Fairfield, SC
Wateree	225.5	13,025	214.9	189.4	5.3	56	183,860	22.6	Lancaster/Kershaw/ Fairfield, SC
Total		79,895	1795.1	1700	54.0	1419	2,072,460	NA	

\* The Project Boundary Line (PBL) values include reservoir full pond shoreline plus the island full pond shoreline miles.

\*\* The Shoreline Management Plan (SMP) values include SMP shoreline plus SMP island shoreline miles. The SMP shoreline contour for each reservoir is based on approximation of the normal summer-time operating level for each reservoir. Catawba/Wateree Data computed from August 2006 SMP GIS data files.

## **Section 3**

# **Overview of the Catawba-Wateree Relicensing Process**

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The licensing process utilized by Duke is the FERC's Traditional Licensing Process (TLP-Regulatory Track) supplemented with the development of a CRA (Stakeholder Agreement Track). This approach has provided the required three-phase consultation process associated with obtaining a new operating license along with the negotiation process that afforded federal, state, and local government agencies as well as non-governmental stakeholders an active role in the relicensing process. The goal has been to reach a mutually acceptable agreement that could be incorporated into the requirements of the New License that represented all interests related to the continued operation of the Project.

## **3.1 The Regulatory Track**

The goal of the regulatory track was to execute the traditional three-phase consultation and study process and complete all study reports so Duke could prepare and submit the license application on time. The result was an innovative and progressive array of studies and other stakeholder tools enveloping not only the 225 river miles including and lying between the Project reservoirs, but also an additional 75 miles of the Wateree River from the Wateree Dam to its confluence with the Congaree River.

The First Stage Consultation began in February 2003 when Duke filed its First Stage Consultation Document with the FERC, thus formally initiating the relicensing process. Duke filed its Notice of Intent with the FERC to relicense the Project on July 21, 2003.

The Second Stage Consultation (August 2003–August 2006) began with the development of detailed study plans, included the actual field studies and development of study reports, and concluded with the filing of the Application for New License with the FERC on August 29, 2006. All study plans, study reports, and resource committee reports were made available for relicensing process participants to review. Relicensing process participants were invited to

comment on reports and Study Teams and Resource Committees considered all comments received. Table 2 lists the studies performed during the stage two consultation.

**TABLE 2**  
**STUDIES PERFORMED DURING THE CATAWBA-WATEREE**  
**RELICENSING PROCESS**

Catawba-Wateree Project Relicensing Studies			
Aquatics 01	Fish Community Survey and Assessment	Cultural 01	Project Cultural Resources Survey
Aquatics 02	Reservoir Fish Habitat Assessment	Cultural 02	Historic Properties Management Plan
Aquatics 03	Diadromous Fish Studies	Cultural 03	Mulberry Site Assessment
Aquatics 04	Instream Flow Assessment	Rec 01	Recreation Use and Needs Study
Aquatics 05	Fish Entrainment Evaluation	Rec 02	Recreation Flow Study
Aquatics 06	Mussel Survey	SMP 01	Shoreline Management Plan Revision
Aquatics 07	Macrobenthic Survey	SMP 02	Shoreline Management Guidelines Revision
Ops 01	Hydrologic/Hydraulic Operations Model	Terrestrial 01	Wetlands Mapping and Characterization
Ops 02	Reservoir Level Study	Terrestrial 02	Floodplain Vegetation Assessment
Ops 03	Trash Management Plan	Terrestrial 03	Great Falls Bypass Botanical Study
Ops 04	Water Supply Study	Terrestrial 04	RTE Species and Habitat Survey
Ops 05	Low Inflow Protocol Study	Terrestrial 05	Breeding and Migratory Bird Study
Ops 06	Maintenance and Emergency Protocol	Terrestrial 06	Great Falls Bypass Wildlife Study
Ops 07	Recreation Flow Communication Study	Water Quality 01	Water Quality of Reservoirs and Riverine Reaches
Ops 08	Wateree High Water Level Management Study		

**Relicensing studies and computer models provided relicensing participants with the ability to analyze the impact of future operating proposals.**

Most studies were repeated at multiple locations on the Catawba-Wateree River system. Several studies extended 75 miles beyond the most downstream hydro development, Wateree, to the confluence of the Wateree and Congaree rivers.

The results of many of these studies have been used to determine compliance with the 401 Water Quality Certification existing use standards. These study results are discussed in more detail in Section 4 (Water Quality Assessment Process), Section 5 (Individual Developments), and Section 9 (Summary and Conclusions) of this Supplemental Information Package (SIP).

The Third Stage Consultation Phase (September 2006–Issuance of New License) began with the filing of the Application for New License with the FERC. The FERC leads this last stage, which includes conducting an independent environmental analysis, establishing conditions to be included in the New License, and concludes with the issuance of the New License.

### **3.2 The Stakeholder Agreement Track**

The CRA is a formal and binding contract among the signing Parties that presents stakeholders' recommendations to FERC for the New License. This is a result of extensive collaboration and negotiations among approximately 80 organizations from both North and South Carolina, producing an equitable, sustainable, long-term, and balanced agreement for the future operations of the Project. The CRA includes both proposed license articles to be included in the New License and other agreements not intended to be included in the New License. Those agreements not included in the New License will be enforceable under state contract law.

The following organizations and individuals have signed and support the CRA:

Duke Energy Carolinas, LLC  
Duke Energy Corporation  
Abitibi Bowater  
Alexander County, NC  
American Whitewater  
Area II Soil & Water Conservation Districts  
Burke County, NC  
Caldwell County, NC  
Carolina Canoe Club  
Catawba County, NC  
Catawba Indian Nation  
Catawba Indian Nation Tribal Historic  
Preservation Office  
Catawba Lands Conservancy  
Catawba Regional Council of Governments  
Catawba Valley Heritage Alliance  
Catawba-Wateree Relicensing Coalition  
Centralina Council of Governments  
Chester Metropolitan District  
City of Belmont, NC  
City of Camden, SC  
City of Charlotte, NC  
City of Gastonia, NC  
City of Hickory, NC  
City of Morganton, NC  
City of Mount Holly, NC  
City of Rock Hill, SC  
Crescent Resources, LLC  
Foothills Conservancy  
Gaston County, NC  
Great Falls Hometown Association  
Harbortowne Marina  
International Paper  
Iredell County, NC  
Kershaw County, SC  
Kershaw County Conservation District  
Lake James Homeowners  
Lake Wateree Association  
Lake Wylie Marine Commission  
Lancaster County Water & Sewer District  
Lincoln County, NC

Lugoff-Elgin Water Authority  
McDowell County, NC  
Mecklenburg County, NC  
Mountain Island Lake Association  
Mountain Island Lake Marine Commission  
North Carolina Dept. of Environment and  
Natural Resources with its Divisions of  
Forest Resources, Parks and Recreation,  
Water Quality, and Water Resources  
North Carolina Wildlife Federation  
North Carolina Wildlife Resources  
Commission  
R & N Marina  
South Carolina Dept. of Archives and  
History  
South Carolina Dept. of Natural Resources  
South Carolina Dept. of Parks, Recreation  
and Tourism  
South Carolina Electric & Gas  
South Carolina Wildlife Federation  
Springs Global US, Inc.  
Town of Davidson, NC  
Town of Great Falls, SC  
Town of Valdese, NC  
Trout Unlimited, Inc.  
Union County, NC  
Wateree Homeowners Association –  
Fairfield County  
Western Piedmont Council of Governments  
York County, SC  
York County Culture & Heritage  
Commission  
William B. Cash  
Shirley M. Greene  
Frank J. Hawkins  
Timothy D. Mead  
Merlin F. Perry  
Joseph W. Zdenek

### **3.3 How Stakeholder Teams Balanced Water Needs**

The results of several studies had to converge in order to equitably utilize the available water supply in the Catawba-Wateree River Basin for all water-based interests (see Figure 2). The CHEOPS model was developed to evaluate operations of all developments simultaneously under various operating scenarios, and provide stakeholders with information on how well or poorly any particular scenario met their individual and collective interests related to water quantity. Input to the CHEOPS model came from the following studies:

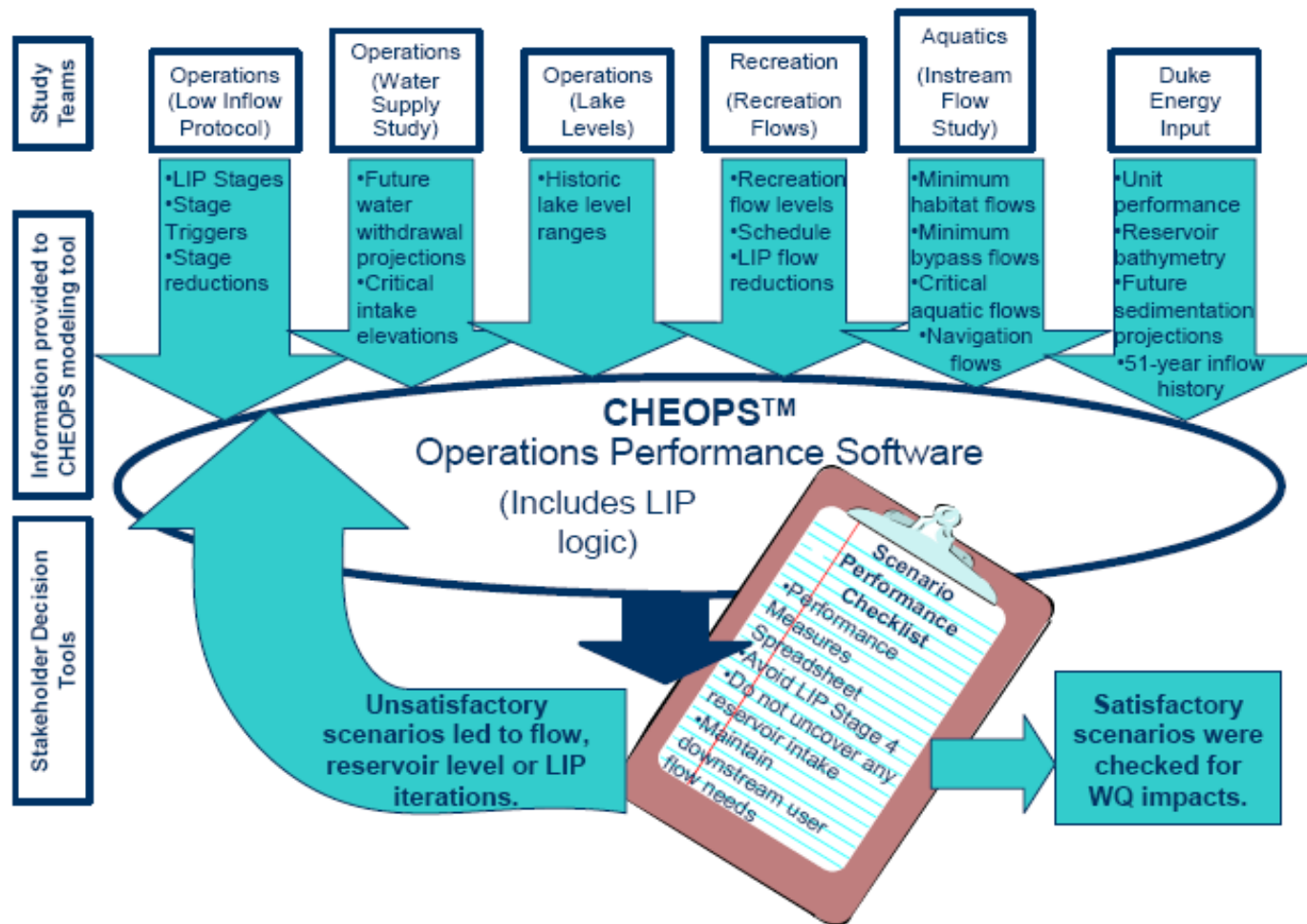
- Low Inflow Protocol (LIP) Study (drought management study)
- Water withdrawal and return projections and water withdrawal intake elevations from the Water Supply Study
- Critical reservoir elevations from the Reservoir Level Study
- Recreation flow levels and schedules from the Recreation Flow Study
- Minimum continuous aquatic habitat flows from the In-stream Flow Study
- Critical flows necessary for aquatic life and for downstream dischargers and withdrawers
- Hydro unit performance, reservoir storage, sedimentation projections, and 51-year inflow history provided by Duke

Output from the CHEOPS model was provided in a stakeholder-specified format called a Performance Measures Spreadsheet, which numerically and graphically enabled stakeholders to determine if their water quantity-based interests were being met by a given operating scenario. Other performance criteria that must be satisfied for each CHEOPS scenario run included:

- Avoid entering LIP Stage 4 (Emergency Water Use Stage).
- Do not uncover any reservoir located water intake.
- Maintain downstream uses and critical flow needs (aquatic, municipal, and industrial).

**FIGURE 2**  
**CHEOPS MODEL USED INPUT FROM VARIOUS STUDIES TO EVALUATE POTENTIAL**  
**PROJECT OPERATING SCENARIOS**

*Catawba-Wateree Project Water-Based Interests*  
*Comprehensive Decision-Making Process*



Once a successful operating scenario was identified, several water quality metrics of that scenario were compared to current-day operations. Factors including nutrient concentration, reservoir dissolved oxygen (DO), reservoir temperature, and reservoir fish habitat were shown either to be unaffected or improved slightly during normal conditions under the operating proposal in the CRA.

Participants on the stakeholder teams used these and other tools to understand how their individual interests affected one another, test whether their proposals could be sustained by the amount of water in the system, and validate the resilience of their proposals in the face of increasing future water demands and severe drought periods.

### **3.4 Benefits of the Comprehensive Relicensing Agreement**

The consensus recommendations of the 70 signatory stakeholder organizations and individuals will improve, balance, and help sustain future power and non-power uses of the Project. The CRA achieves an impressive balance among competing water uses and needs while improving water quality in the Catawba-Wateree River Basin.

In this 401 certification SIP, these CRA provisions addressing water needs and existing uses are supplemented with the modeling of proposed equipment modifications necessary to meet applicable numeric water quality standards. Ten years of DO monitoring data were analyzed under new CRA flow and reservoir conditions. This resulting application provides the basis to certify that the operations of the Project under a New License with the proposed applicable CRA provisions and water quality modifications will enable Duke to meet applicable existing use and numeric standards requirements in accordance with Section 401 of the Clean Water Act.

The CRA also includes administrative provisions relative to the water quality certification and FERC processes. The following administrative provisions have been excerpted from the CRA (refer to the CRA for exact language):

- All Parties agree that Duke shall include the Flow and Water Quality Implementation Plan (FWQIP) (see Table 4 in the NC 401 Water Quality Application and CRA Appendix L), and the Water Quality Monitoring Plan (WQMP) (see CRA Appendix F) with its applications for 401 Water Quality Certifications as recommended plans for the Project. All Parties, except the North Carolina Department of Environment and Natural Resources (NCDENR), agree that the FWQIP shall be recommended to be a condition of the 401 Water Quality Certifications.
- After a New License is received, Duke will file the FWQIP and the WQMP with the FERC for approval. This filing will include the FWQIP and WQMP that have been certified by the state water quality agencies along with any engineering and construction details determined to be needed. The Parties acknowledge that, except for the replacement of the Bridgewater Powerhouse, Duke shall not begin implementation of the FWQIP or the WQMP until the FERC has approved these plans.
- Duke will initiate interim changes to current operation at selected Project developments that require physical equipment additions or modifications in accordance with the FWQIP. Duke shall initiate the Interim Measures for Providing Aquatic Flow and/or DO Enhancement until physical modifications are complete as identified in the FWQIP within 60 days following the issuance of the New License. The interim measures will continue at each dam or powerhouse until completion of the permanent modification.
- Unless operating in accordance with the LIP and/or the Maintenance and Emergency Protocol, Duke shall operate the hydro units at the powerhouses identified for Interim Measures in the FWQIP in the following manner:
  - When Duke is providing flow releases, reservoir level control, and/or generation with any of these powerhouses at times that DO in the flow release is below 401 Water Quality standards, Duke will operate the available hydro units with the greatest existing DO enhancement capability in a first-on, last-off hierarchy. Duke will use all the DO enhancement capability available on all hydro units that are

subsequently operated at that powerhouse, if needed, in its best efforts to raise DO levels.

- If Total Maximum Daily Loads (TMDL) are developed within the FERC Project Boundaries (or on the Catawba and Wateree rivers and their associated floodplains and bottomlands from Lake James downstream to the confluence of the Wateree River with the Congaree River) for pollutants that are introduced as a direct result of operation of Project facilities, Duke will actively consult with the appropriate state agencies including, but not limited to, data-sharing, modeling, and sampling, to determine what role, if any, Project operations play in managing the pollutant.
- If, after all planned flow delivery and water quality enhancement modifications required in the FERC-approved FWQIP have been completed, a chronic non-compliance with 401 Water Quality Certification requirements exists as a result of Duke's hydroelectric operations, Duke will immediately consult with South Carolina Department of Health and Environmental Control (SCDHEC) and/or the North Carolina Division of Water Quality (NCDWQ) as appropriate to confirm the assessment of the non-compliance and the proposed corrective action(s). Duke will continue, in consultation with NCDWQ and/or SCDHEC, to develop an implementation plan for corrective actions.
- If Duke believes that an inability to comply with any terms or conditions of any 401 Water Quality Certification is not attributable to Duke's operations or is attributable to increased waste loadings (compared to waste loadings present at the time of Project equipment installation) from point or non-point sources, Duke may provide data to NCDWQ and/or SCDHEC as appropriate to (i) help determine whether it is Duke's operations or other sources that are causing Duke's inability to comply and/or (ii) support any TMDL proceeding or other corrective actions to address these point and non-point source loadings.

The stability and success of the negotiated CRA is sensitive to regulatory decisions (such as North Carolina and South Carolina 401 State Water Quality Certifications and articles in the

New License issued by the FERC). Material changes to the proposed License Articles could upset the balance and benefits negotiated by the stakeholders and may lead to the potential for Parties to withdraw from the CRA or for the entire CRA to be terminated. Therefore, the Parties to the CRA respectfully request that the states of North Carolina and South Carolina regard the Parties' intentions and adopt the water quality provisions of the CRA as conditions of the 401 certification without material modification.

### **3.5 Applicable Sections of the CRA**

The CRA covers a wide range of operating and resource topics, some of which are not related to water quality certification. The water quality certification should be based on the following applicable sections of the CRA:

- 2.0: Reservoir Elevation Agreements
- 4.0: Habitat Flow Agreements
- 6.0: Low Inflow Protocol Agreements
- 7.0: Maintenance and Emergency Protocol Agreements
- 13.0: Water Quality Agreements
- 15.0: Gauging and Monitoring Agreements Sections 15.1 through 15.5
- Appendix A: Proposed License Articles Sections A-1.0, A-3.0, A-4.0, A-5.0, and A-6.0
- Appendix A: Proposed License Articles Section A-2.0 for Maximum Flows, Wylie High Inflow Protocol, Flows Supporting Public Water Supply and Industrial Processes, and Flow and Water Quality Implementation Plan
- Appendix C: Low Inflow Protocol (LIP) for the Catawba-Wateree Project
- Appendix D: Maintenance and Emergency Protocol (MEP) for the Catawba-Wateree Project
- Appendix F: Water Quality Monitoring Plan
- Appendix L: Flow and Water Quality Implementation Plan

## Section 4

# Water Quality Assessment Process

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The purpose of this section is to give water quality resource agencies and interested reviewers an explanation of how water quality was addressed in the Catawba-Wateree Relicensing Process and where to find the necessary analyses and findings in this application. The water quality assessment process utilized for the Project can be explained in three distinct phases:

1. Existing aquatic resources and uses (Section 4.1)
2. Discrete Bubble Model (DBM) analysis of proposed aeration modifications (Section 4.2)
3. Assessment of operating scenarios (Section 4.3)
4. Quality Assurance Project Plan (QAPP) (Section 4.4)

### 4.1 Existing Aquatic Resources and Uses

Water quality regulations require (1) that waters be suitable for aquatic life propagation and maintenance of biological integrity, wildlife, secondary recreation, and agriculture; and (2) that sources of water quality pollution that preclude any of these uses on either a short-term or long-term basis be considered in violation of a water quality standard. This water quality standard addresses the need for any receiving waters to be of suitable quantity and to not degrade existing aquatic communities.

The Project relicensing process determined the menu of aquatic resources and uses potentially affected by hydroelectric operations that needed to be studied. A full list of studies is presented in Section 3 (Overview of the Catawba-Wateree Relicensing Process) of this SIP. Additional information about the studies that specifically focused on aquatic resources and other existing uses is summarized in Table 3. These studies were planned and conducted in consultation with representatives from state and federal resource agencies, and others who participated on the Water Quality, Aquatic, and Terrestrial Resource Committees. This process provided for thorough assessments of the aquatic resources of the Project as well as a basis for stakeholder negotiations leading to the CRA.

**TABLE 3**  
**STUDIES RELATED TO THE AQUATIC RESOURCES OF THE**  
**CATAWBA-WATEREE PROJECT**

<b>Title (Designation)</b>	<b>Description</b>	<b>Objectives</b>
Fish Community Survey and Assessment (Aquatics 01)	Survey of Fish Communities within and Adjacent to the Project Area	<ul style="list-style-type: none"> <li>■ Conduct fish community surveys, including small non game species, in bypasses, tailrace areas, riverine reaches, and major tributaries of the Project</li> <li>■ Conduct field sampling to assess presence and relative abundance of robust and Carolina redhorses and highfin carpsuckers in the free-flowing river reaches downstream of Bridgewater, Wylie, and Wateree Developments</li> </ul>
Reservoir Fish Habitat Assessment (Aquatics 02)	Determine the shallow water fish habitat available in reservoir water level fluctuation zones and determine the relationship of habitat to Project operations	<ul style="list-style-type: none"> <li>■ Identify magnitude, season frequency, and duration of water level fluctuations in each reservoir.</li> <li>■ Evaluate vertical distributions of the major types of shallow water fish habitat (i.e., emergent vegetation, large woody debris, riprap and piers), along with clay, sand, and cobble substrates that are included and defined in Duke's current Catawba-Wateree Shoreline Management Plan.</li> <li>■ Assess changes in the lake-wide surface area of these habitat types under various water level changes associated with Project operations.</li> </ul>
Diadromous Fish Studies (Aquatics 03)	Evaluate status and potential for diadromous fish restoration in the Catawba-Wateree River	<ul style="list-style-type: none"> <li>■ Document the current usage of the Wateree River, below Wateree Dam, by target diadromous species during spawning seasons.</li> </ul>
Instream Flow Assessment (Aquatics 04)	Determination of aquatic habitat at various flows in downstream river and bypassed stream reaches	<ul style="list-style-type: none"> <li>■ Quantify or otherwise assess the relationship of flow to aquatic habitat in selected downstream river and bypassed stream reaches.</li> </ul>
Mussel Survey (Aquatics 06)	Survey of Mussel Populations in the Project Area	<ul style="list-style-type: none"> <li>■ The study objective is to conduct a field survey of mussels at sites along the Catawba River that are within the Project boundary or within the zone of Project influence. Each survey is designed to provide basic information concerning mussel occurrence with special emphasis on Protected, Endangered, Threatened and Special Concern (PETS) species that might be identified in the areas.</li> </ul>
Macrobenthic Survey (Aquatics 07)	Describe the aquatic macroinvertebrate assemblages associated with the Catawba-Wateree Project and evaluate any potential Project-related impacts	<ul style="list-style-type: none"> <li>■ The study objective is to provide basic information about hydro-related macrobenthic communities and evaluate any potential Project-related effects on macrobenthic resources.</li> </ul>

Title (Designation)	Description	Objectives
RTE Species and Habitat Survey (Terrestrial 04)	Document any known or potentially occurring rare, threatened, and endangered (RTE) plant and wildlife species within the Project boundary and areas within the Project influence	<p>The objectives of this RTE plant and wildlife study are to:</p> <ul style="list-style-type: none"> <li>■ Document the occurrence of RTE species within the Project area;</li> <li>■ Assess the potential effects of Project-related current and proposed hydropower operations areas on the species and critical habitats; and</li> <li>■ Provide information to assist in developing any potential protection, mitigation, and enhancement (PM&amp;E) measures.</li> </ul>

As part of the consultation process, Resource Committee members developed reports based on study results to inform stakeholders of:

- The overall status and condition of the resource and identify problems that may exist;
- Potential sources of the problems affecting the resource; and
- Recommended Project engineering or operational changes to achieve stakeholder expectations for each resource.

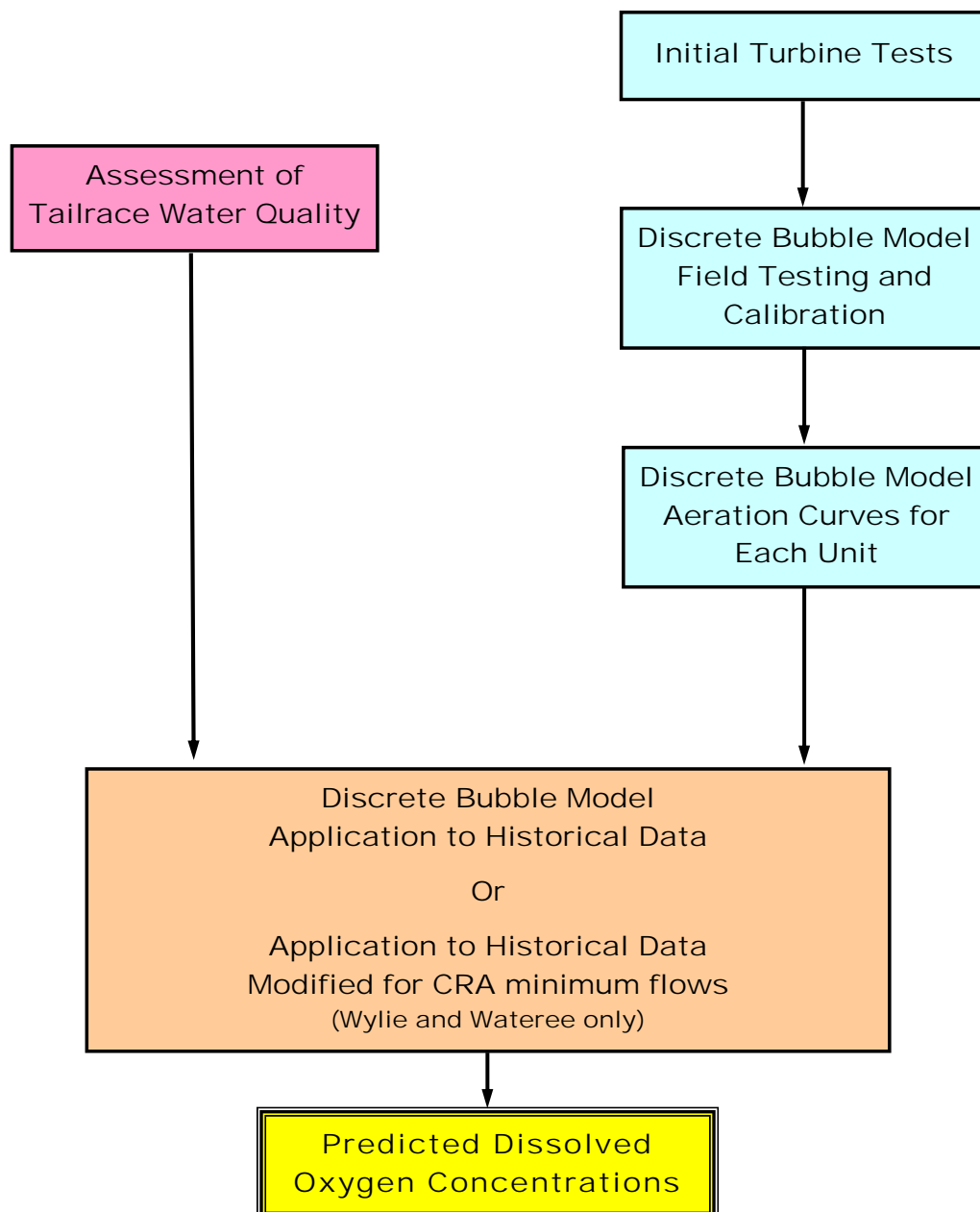
Recommended operational changes to benefit existing resources frequently called for water quality improvements, increased flow releases into riverine sections of the Project, and higher reservoir level controls. These operational changes conflicted with each other and had to be balanced not only with each other, but with future water needs and uses throughout the basin in both North Carolina and South Carolina for the long term (50 years).

The balancing process explained in detail in Section 3 (Overview of the Catawba-Wateree Relicensing Process) of this SIP was used to create a sustainable basin-wide, long-term operating plan that also succeed at achieving enhancement goals for existing uses. If at any location resource goals were not achieved, mitigation by Duke was agreed to (refer to Section 6 [Flow Mitigation Package] of this application). Each Project development is discussed in Section 5 (Individual Developments) of this SIP, including the existing uses considered and how they were addressed and enhanced.

## 4.2 Discrete Bubble Model Analysis of Proposed Aeration Modifications

The process used to evaluate compliance with water quality standards for the water released from each development is summarized in the following chart:

**FIGURE 3**  
**DISCRETE BUBBLE MODEL APPLICATION AND CALIBRATION FOR THE**  
**CATAWBA-WATEREE PROJECT**



### 4.2.1 Assessment of Tailrace Water Quality

Beginning in 1992 as a research project at Lookout Shoals tailrace, installation of electronic equipment for water quality monitoring at 5-minute intervals (temperature, DO, conductivity, and pH) was completed for all Project development tailraces by 1996 (refer to Duke Energy 2006 for detailed methodology and time series plots). For 5 years beginning in 1997, water samples were collected in the tailraces at 2-week intervals. Detailed nutrient, metal, and ionic composition analyses were performed on these bi-weekly samples. This tailrace water quality data, collected at such frequency, provided detailed information regarding station operation and clearly demonstrated that all applicable state water quality standards were met year-round, with the exception of DO, in the turbine releases.

The water quality numerical assessments presented in this application are based on multiple years of water quality sampling preceding the Catawba-Wateree Relicensing Process and additional sampling conducted in 2004 as part of the relicensing process. This is a more extensive database than is commonly available for most certification processes. This extensive data range (1) reflects a comprehensive range of hydrologic (temperature and DO) and operational (flow release rates and unit operating combinations) conditions which are evaluated in this application and (2) helps to assure the adequacy and resiliency of the proposed DO enhancement measures better than could be anticipated based on the more typical 1 to 2 years of water quality sampling. Most importantly, this extensive database allowed a detailed analysis and evaluation of DO compliance with state standards.

In 1995, Duke began evaluating options to increase the DO in the turbine releases. Technologies such as forebay aeration (air and liquid oxygen injection), turbine venting, forebay structures (curtains, walls, weirs, etc.), tailrace aeration weirs, and direct air injection were evaluated for each Project development. Analysis of the long-term DO database provided the design criteria for evaluation of the various options. Turbine venting was the technology of choice due to cost effectiveness, long-term reliability, rapid introduction of oxygen, and the immediate response of increased DO to the turbine flow.

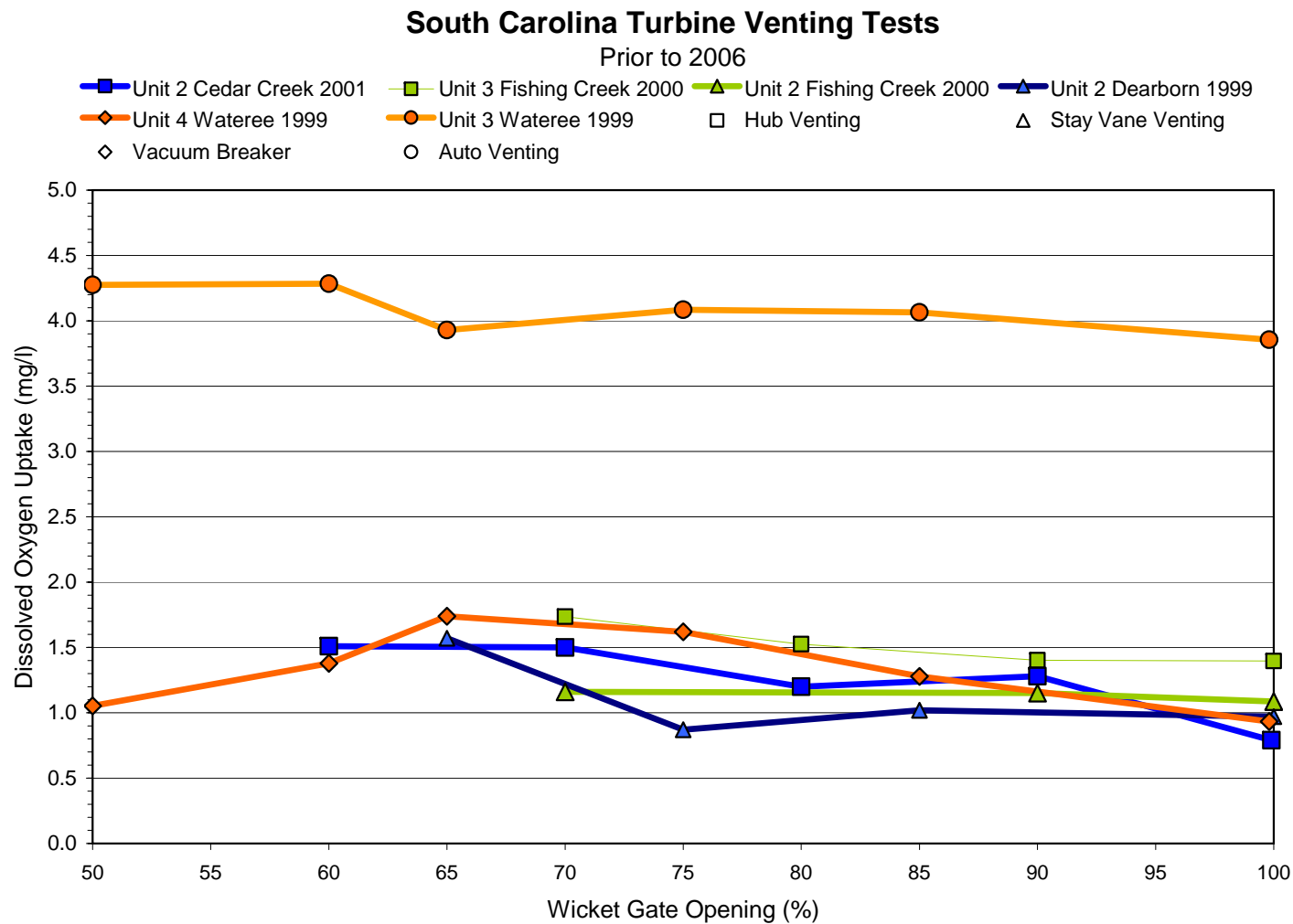
Turbine venting was also considered the preferred aeration technique for the Project based on its proven applicability at other hydropower projects. It is estimated that some form of turbine venting is used or is being planned at over 70 hydropower projects throughout the country. Based on these evaluations, turbine venting modifications were completed as Duke upgraded some of the hydro units as part of the refurbishment program in the 1990s.

#### 4.2.2 Initial Turbine Tests

As individual unit modifications were completed, DO uptake studies were performed to evaluate the amount of DO added to the released water. Results of these early turbine venting studies clearly showed that autoventing (air released at the trailing edge of the turbine runner) was superior to other forms of turbine venting (Figure 4). However, because autoventing turbines could not be retrofitted to existing turbines, existing turbines had to be replaced entirely. Even though hub and stay vane venting were not as efficient as the recently invented autoventing technology, they were options that could be retrofitted to existing turbines at a reasonable cost. The results of field testing were highly variable (Figure 4), with oxygen uptake values typically lower at higher flow rates (greater wicket gate openings). Although the results of these initial turbine tests were encouraging, the data could not be used for predictive purposes to evaluate the use of turbine venting for compliance with DO standards.

Clearly, a method was needed to be able to predict the effectiveness of turbine venting as a means to meet state DO standards. The turbine venting aeration at each station must meet DO standards for all future flow conditions (e.g., single-unit flows, multi-unit flows, and minimum flows) at all levels of incoming DO. The station operations and tailrace DO concentrations measured during the long-term monitoring program will be used to evaluate future aeration effectiveness and DO compliance.

**FIGURE 4**  
**RESULTS OF TURBINE VENTING TESTS PRIOR TO 2006**



### 4.2.3 Discrete Bubble Model – Field Testing and Calibration

The DBM was selected for use on the Project because it includes a more mechanistic description of the factors affecting gas transfer and has several advantages over previous turbine venting models for predicting aeration beyond the range of conditions for which data are available and the models are calibrated. In its simplest form, the bubble model takes the form:

$$\Delta DO = E (DO_{\text{sat}} - DO_{\text{in}})$$

Where:

DO = DO concentration

$\Delta DO$  = DO concentration increase across the turbine

$DO_{\text{sat}}$  = saturation DO at local temperature and pressure

$DO_{\text{in}}$  = DO incoming to the hydroplant

E = aeration efficiency (dimensionless, varies from 0 to 1 depending on physical factors)

$DO_{\text{sat}}$  decreases as water temperature increases, and increases as draft tube pressure increases.

If  $DO_{\text{in}} = DO_{\text{sat}}$ , there is no uptake of DO across the plant ( $\Delta DO = 0$ )

E increases with:

Decreasing water temperature

Time of travel through the draft tube (function of draft tube length, diameter, and turbine flow)

Pressure in the draft tube (function of how deep the draft tube extends below tailwater level)

Smaller bubble size and bubble distribution in the draft tube flow (function of turbine flow)

Air flow rate (function of turbine elevation above tailrace level, turbine flow, air valve inlet size)

Turbine flow (function of turbine design, net hydraulic head, wicket gate opening)

Tailrace elevation (function of total plant flow)

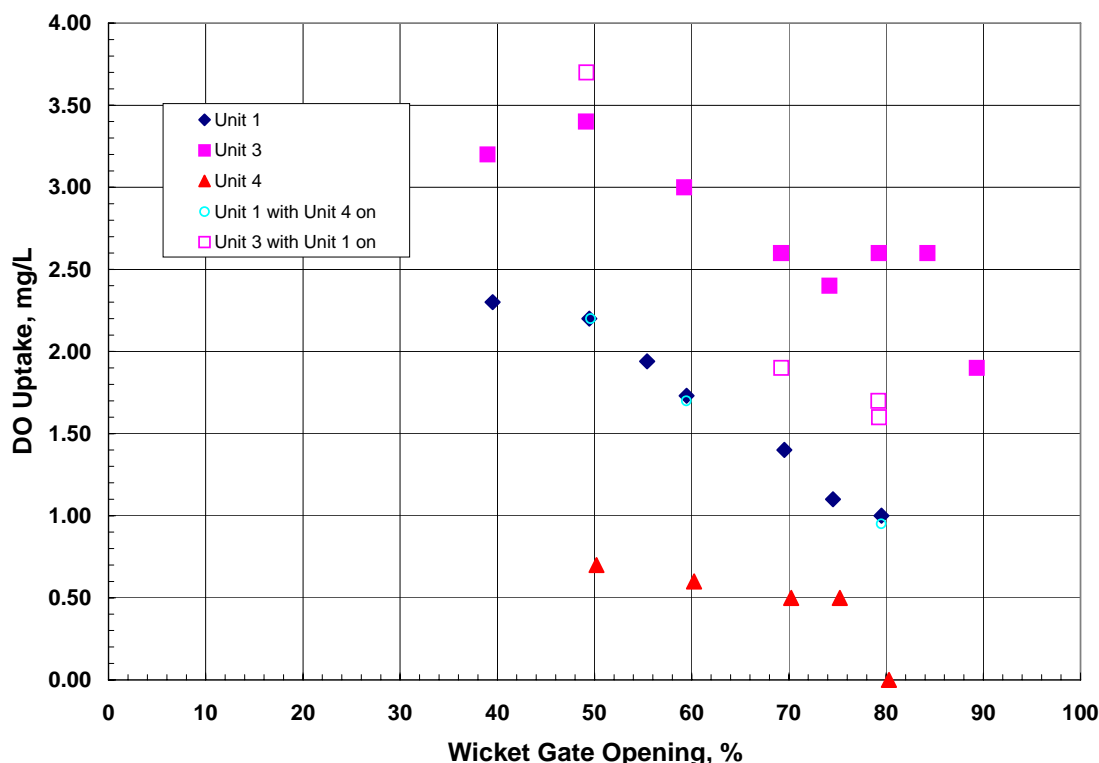
Field testing the Project turbines for application to the DBM was initiated in 2002 at the Wylie Development, and the remaining developments were tested in 2006. The basic protocol for field testing was to vary the unit flow, starting with the lowest flow with no aeration, and to repeat the flow with aeration. Incrementally the flow was increased, and the procedure repeated. At each flow setting and aeration setting (on or off), the following parameters were measured:

- Power Output (MW)
- Wicket Gate Setting (%)
- Forebay Elevation (ft)
- Tailrace Elevation (ft)
- Air Flow into Turbine (modified bell mouths) (cfs)
- Head Cover Pressure (Pa)
- Water Temperature (°C)
- Tailrace DO without Aeration (measured in the flow as it left the turbine) (mg/l)
- Tailrace DO with Aeration (measured in the flow as is left the turbine) (mg/l)

For a complete discussion of the methodology, equipment, and procedures, please refer to the Wylie model report presented in Appendix B.

Using the Wylie Development as an example to illustrate the development and use of the DBM, the initial calibration of the DBM was the relationship of DO uptake and unit water flow (Figure 5).

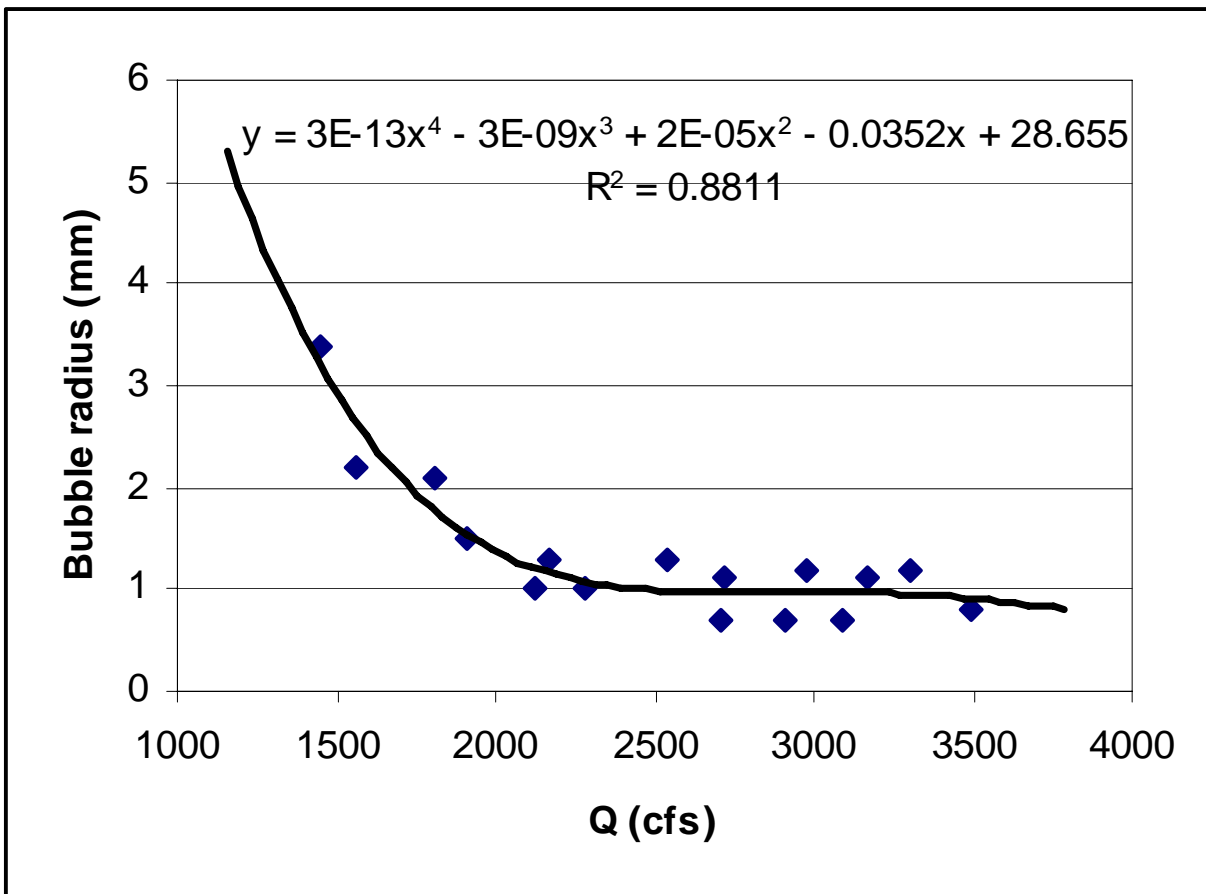
**FIGURE 5**  
**PRELIMINARY DATA ASSESSMENT OF WYLIE TURBINE VENTING TEST FOR**  
**DISCRETE BUBBLE MODEL**



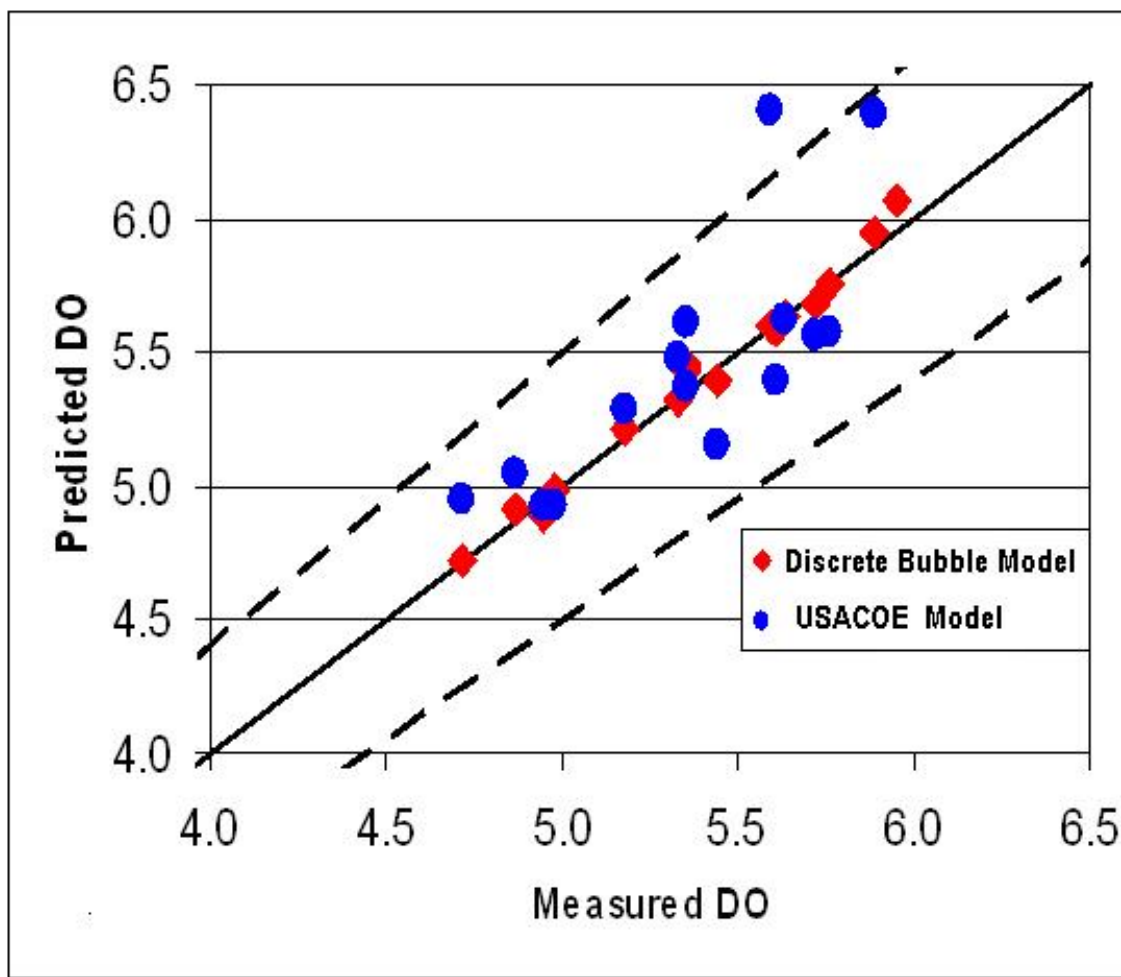
Calibration of the DBM to each hydro unit tested began with performing regression analyses on various interrelated parameters. For example, tailwater elevation is a function of total hydro station flow, percent decrease in air flow is a function of increase in tailwater elevation, turbine air flow is a function of turbine water flow, etc. The geometry of the draft tube (unique for each unit) was developed and incorporated into the DBM program (draft tube geometry, along with unit water flow determines water velocity, bubble size, and travel time). Next, using the variables in the equation (e.g., DO measured in the turbine inflow, the DO measured in the outflow, airflow into the turbine, temperature, hydro station flow, and tailwater elevation), the model was iteratively run to find the bubble size that most closely matched the measured DO. The initial bubble size versus hydro station flow was then plotted; the resulting data has been found usually to fit a power curve (Figure 6). It is then possible to calculate outflow DO based on the bubble size relationship to the turbine flow. Using this method, the predicted outflow DO

is very close to the measured outflow DO, as shown in Figure 7. For a complete discussion of DBM calibration, see Appendix C.

**FIGURE 6**  
**CALIBRATED BUBBLE SIZE WITH PROJECT FLOW**



**FIGURE 7**  
**COMPARISON OF MEASURED DISSOLVED OXYGEN TO DBM-PREDICTED DO**

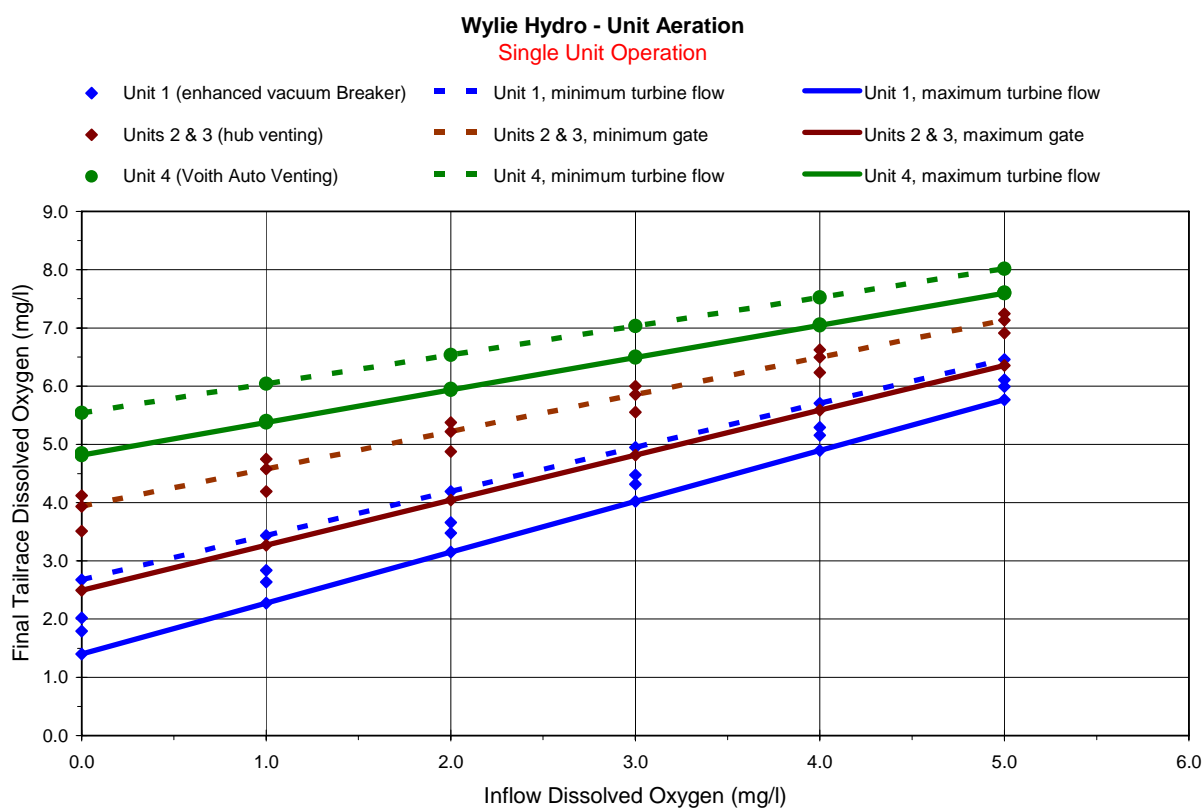


Using the general process described above, a DBM unique to each turbine was calibrated from the field data. Complete field aeration data (air flow, water flow, initial DO, temperature, DO uptake, and turbine power output) was collected in 2002 for two units at Wylie and in 2006 for 12 units at other Catawba-Wateree developments. Units were chosen for field testing if the units were unique or representative of other identical units (turbine size, draft tube geometry, air inlet configuration, etc.). A DBM was also developed for future units at Rhodhiss, Oxford, Wylie, and Wateree. For the new units specified by the CRA at Wylie and Wateree, an existing DBM matching the turbine configuration (e.g., draft tube geometry) was used with the air flow modified and the water flow changed to match the flow levels required by the CRA.

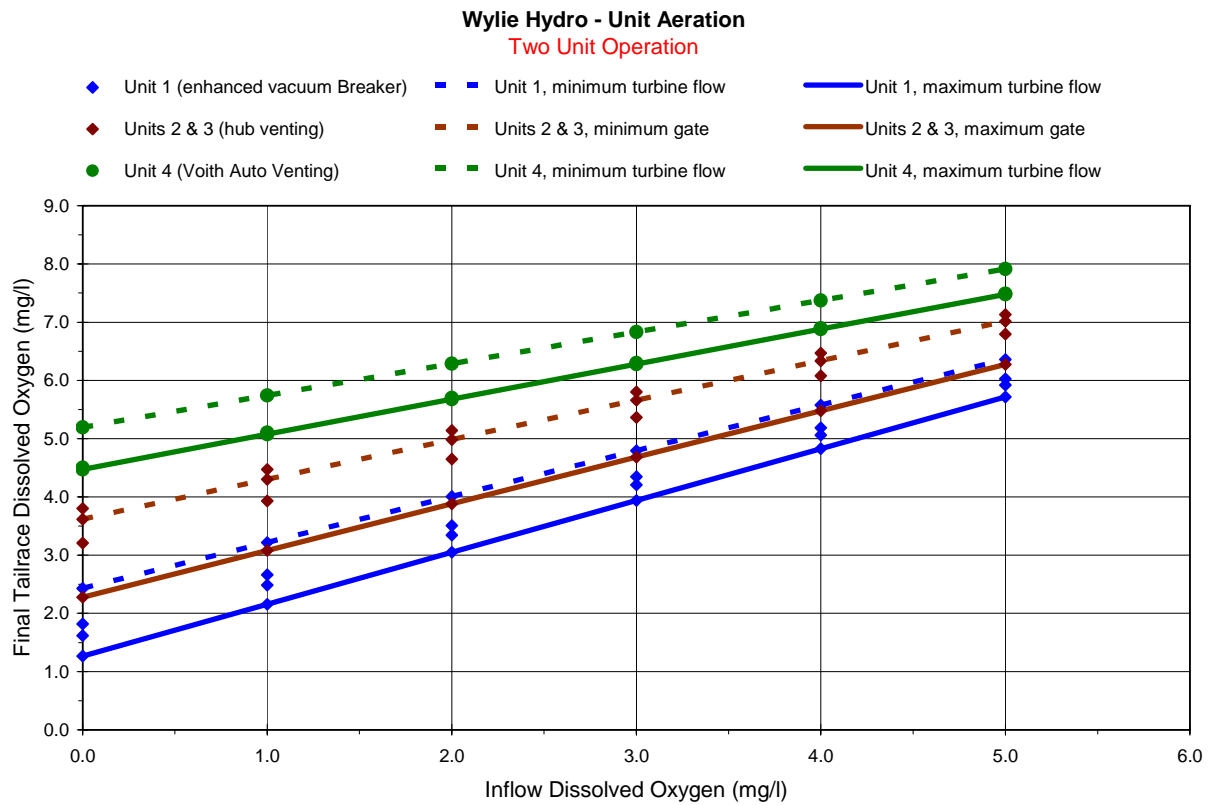
#### 4.2.4 Discrete Bubble Model – Aeration Curves for Each Unit

A calibrated DBM was applied to each turbine at each hydroelectric development in the Project and used as a tool to predict the effectiveness of existing and future turbine aeration capabilities. The model was also used to evaluate piping modifications needed to provide additional air flow to the water in the turbine. Unit aeration capabilities were developed for each development (Figures 8 through 10, using the Wylie Development as an example).

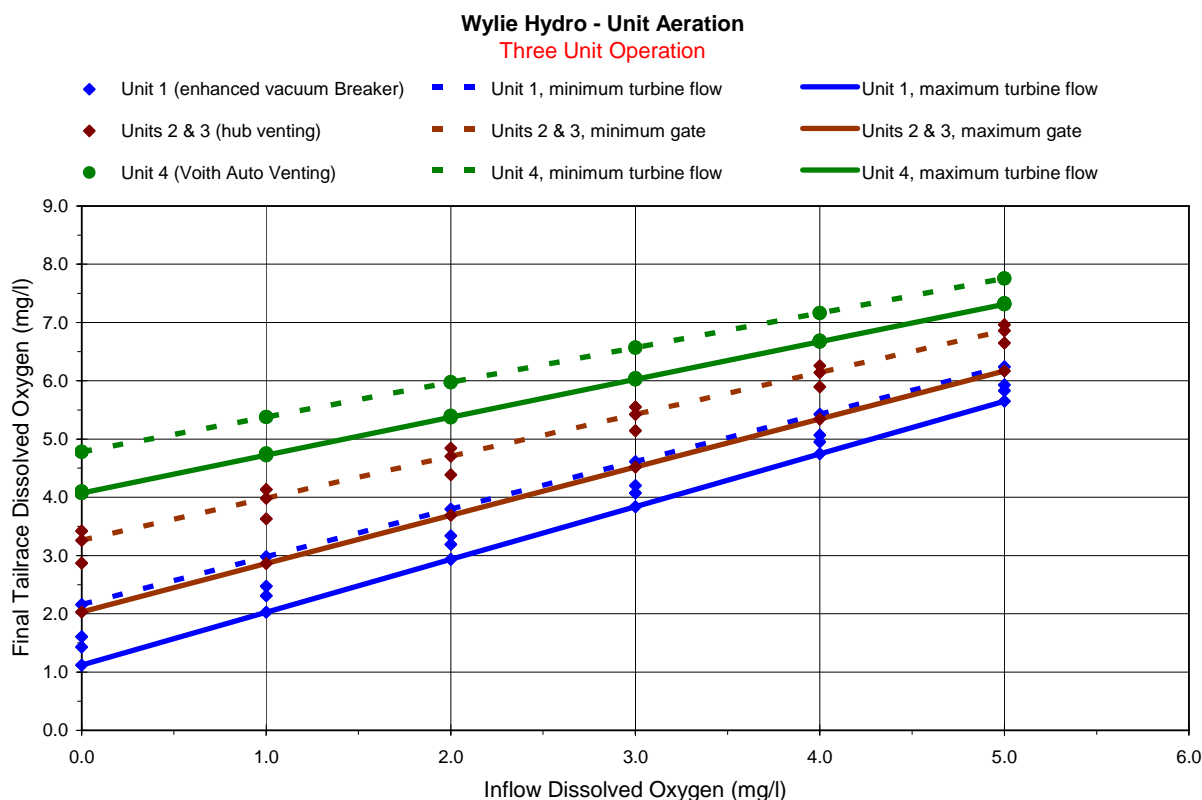
**FIGURE 8**  
**AERATION CAPABILITY OF THE THREE UNIT TYPES AT THE WYLIE DEVELOPMENT UNDER ONE-UNIT OPERATION**



**FIGURE 9**  
**AERATION CAPABILITY OF THE THREE UNIT TYPES AT THE WYLIE**  
**DEVELOPMENT UNDER TWO-UNIT OPERATION**



**FIGURE 10**  
**AERATION CAPABILITY OF THE THREE UNIT TYPES AT THE WYLIE**  
**DEVELOPMENT UNDER THREE-UNIT OPERATION**



These plots represent graphically what the DBM computes mathematically for each turbine flow, total hydro station flow, inflowing DO, and temperature. Even though the aeration appears similar at all hydro station flows, in reality, as the hydro station flow increases, the tailwater elevation increases, thereby slightly decreasing the air flow to the units. This in turn causes a slight decrease in the DO added to the released water. As can be seen in the Wylie examples, the future autoventing turbine is assumed to be Unit 4 and will have the highest DO uptake (specifically designed to aerate), whereas the aeration from Unit 2 generally exceeds the aeration capacity of Unit 1.

#### 4.2.5 Application of the Discrete Bubble Model to Hourly Historical Data

The evaluation of turbine venting to meet state DO standards was conducted by applying the appropriate, calibrated DBM to each turbine at each hydro development. Hourly data (measured hydro station flows, temperature, and DO from the continuous monitoring record) were used as input to the calibrated turbine DBM models at each development.

At Wylie and Wateree, in order to use the DBM to predict future DO in the released water, the historic project flows had to be re-allocated to account for the future continuous minimum flow through a new unit as specified by the CRA. The redistribution of project flow was calculated for each day (from midnight to midnight, tailrace DO monitoring data). The hourly station flows were re-allocated as follows:

1. Determine the total volume of water released from midnight to midnight (acre-ft).
2. On the given day, allocate continuous minimum flow for each hour that water was not released.
3. Determine the total volume of water released as continuous minimum flow (acre-ft). This water will be released through the new minimum flow unit.
4. Subtract minimum continuous volume from total daily volume.
5. Allocate remaining water to generation from Units 2, 3, or 1 in proportion to historic hourly flow.
6. When the allocated generated flow exceeded the capacity of one unit, then subsequent units were assumed to operate.

Using two different days from the Wylie Development as examples, the original hourly station flow (actual releases from the historic database) is shown. The reallocated station flow (allocated to continuous minimum flow) is also shown. The total volume of water (acre-ft) released during the 24-hour period was the same. Notice by comparing the original flow and the CRA flow that the amount of water used for peak generation is reduced by the amount necessary to maintain the continuous minimum flow.

The new station flow was further allocated to the various units, beginning with the continuous minimum flow to Unit 4 (future autoventing turbine designed specifically for the continuous minimum flow). During generation periods, Unit 4 was not operated, but rather flow allocated to the other three units based upon each unit's flow capacity and range of operations. Since DO in the water flowing into the turbines is a function of flow rate and withdrawal zone, another adjustment to DO is needed in order to compensate for the altered future flow rates through Wylie and Wateree units. Some of the possible ways are (1) matching DO and flow by the hour of the day in which they occur, (2) applying a single daily average of all hourly DOs to all generation hours, (3) applying a single flow-weighted daily average of all hourly DOs to all generating hours, or (4) applying a single lowest generating DO of the day to all generation hours.

The DO concentrations assigned as input to the DBM were assumed to be (1) the minimum observed DO during a 24-hour period (very conservative estimate), and (2) flow-weighted DO (more realistic estimate). Since the minimum DO method was extremely conservative and the flow-weighted method was probably closer to expected values, both of these methods were used for the DBM predictions to illustrate the capabilities of the turbine venting with poorer oxygen conditions than would be actually realized. Illustrative results for Wylie are shown in Tables 4 through 7.

**TABLE 4**  
**DISCRETE BUBBLE MODEL APPLICATION TO PREDICT FUTURE STATION**  
**TAILRACE DISSOLVED OXYGEN: EXAMPLE OF FLOW ALLOCATION TO THE**  
**WYLIE DEVELOPMENT ON A DAY WITH LIMITED GENERATION AND LOW**  
**INFLOW DISSOLVED OXYGEN USING THE MINIMUM DAILY DISSOLVED**  
**OXYGEN VALUE**

Date / Time	Historical Flows				Future CRA Flows									
				All Units	Unit 1		Unit 2		Unit 3		Unit 4		Station	
	Station (cfs)	Station Temp (°C)	Station DO (mg/l)	Inflow DO [min method] (mg/l)	Turbine Flow (cfs)	DBM Tailrace DO (mg/l)	Turbine Flow (cfs)	DBM Tailrace DO (mg/l)	Turbine Flow (cfs)	DBM Tailrace DO (mg/l)	Turbine Flow (cfs)	DBM Tailrace DO (mg/l)	Total Generation Flow (cfs)	Tailrace Hourly DO (mg/l)
7/15/98 0:00	139	28.06	2.08	1.74	0		0		0		1100	5.79	1100	5.79
7/15/98 1:00	80	27.55	2.23	1.74	0		0		0		1100	5.82	1100	5.82
7/15/98 2:00	80	27.43	2.29	1.74	0		0		0		1100	5.83	1100	5.83
7/15/98 3:00	80	27.19	2.44	1.74	0		0		0		1100	5.85	1100	5.85
7/15/98 4:00	80	26.95	2.37	1.74	0		0		0		1100	5.86	1100	5.86
7/15/98 5:00	1996	27.62	2.23	1.74	0		0		0		1408	5.81	1408	5.81
7/15/98 6:00	382	27.96	1.76	1.74	0		0		0		1100	5.80	1100	5.80
7/15/98 7:00	80	27.75	1.74	1.74	0		0		0		1100	5.81	1100	5.81
7/15/98 8:00	373	27.51	2.05	1.74	0		0		0		1100	5.83	1100	5.83
7/15/98 9:00	2147	27.95	2.25	1.74	0		0		0		1514	5.79	1514	5.79
7/15/98 10:00	199	28.23	2.01	1.74	0		0		0		1100	5.78	1100	5.78
7/15/98 11:00	2416	28.23	2.62	1.74	0		0		1704	5.49	0		1704	5.49
7/15/98 12:00	1033	28.38	2.51	1.74	0		0		0		1100	5.78	1100	5.78
7/15/98 13:00	1993	28.32	2.65	1.74	0		0		0		1406	5.77	1406	5.77
7/15/98 14:00	4111	28.6	3.57	1.74	0		0		2900	5.13	0		2900	5.13
7/15/98 15:00	5886	28.98	4.13	1.74	0		2076	4.76	2076	4.76	0		4152	4.76
7/15/98 16:00	5894	29	4.07	1.74	0		2079	4.76	2079	4.76	0		4157	4.76
7/15/98 17:00	5889	28.95	4.07	1.74	0		2077	4.76	2077	4.76	0		4154	4.76
7/15/98 18:00	3459	28.63	3.18	1.74	0		0		2440	4.65	0		2440	4.65
7/15/98 19:00	2490	28.4	2.66	1.74	0		0		1756	5.43	0		1756	5.43
7/15/98 20:00	2292	28.37	2.58	1.74	0		0		0		1617	5.77	1617	5.77
7/15/98 21:00	190	28.32	2.06	1.74	0		0		0		1100	5.78	1100	5.78
7/15/98 22:00	80	28.18	1.90	1.74	0		0		0		1100	5.79	1100	5.79
7/15/98 23:00	138	27.48	2.22	1.74	0		0		0		1100	5.83	1100	5.83
Daily Average DO =													5.57	

**TABLE 5**  
**DISCRETE BUBBLE MODEL APPLICATION TO PREDICT FUTURE STATION**  
**TAILRACE DISSOLVED OXYGEN: EXAMPLE OF FLOW ALLOCATION TO THE**  
**WYLIE DEVELOPMENT ON A DAY WITH SIGNIFICANT GENERATION AND LOW**  
**INFLOW DISSOLVED OXYGEN USING THE MINIMUM DAILY DISSOLVED**  
**OXYGEN VALUE**

Date / Time	Historical Flows				Future CRA Flows										
	Station (cfs)	Station Temp (°C)	Station DO (mg/l)	All Units  Inflow DO [min method] (mg/l)	Unit 1		Unit 2		Unit 3		Unit 4		Station		
					Turbine Flow (cfs)	DBM Tailrace DO (mg/l)	Turbine Flow (cfs)	DBM Tailrace DO (mg/l)	Turbine Flow (cfs)	DBM Tailrace DO (mg/l)	Turbine Flow (cfs)	DBM Tailrace DO (mg/l)	Total Generation Flow (cfs)	Tailrace Hourly DO (mg/l)	
7/21/98 0:00	2132	28.72	2.82	2.22	0		0		1990	5.34		0		1990	5.34
7/21/98 1:00	3395	28.62	3.14	2.22	0		0		3168	5.39		0		3168	5.39
7/21/98 2:00	80	28.6	2.60	2.22	0		0		0			1100	6.03	1100	6.03
7/21/98 3:00	80	28.4	2.71	2.22	0		0		0			1100	6.04	1100	6.04
7/21/98 4:00	80	28	3.02	2.22	0		0		0			1100	6.06	1100	6.06
7/21/98 5:00	80	27.7	3.14	2.22	0		0		0			1100	6.08	1100	6.08
7/21/98 6:00	80	27.5	3.18	2.22	0		0		0			1100	6.09	1100	6.09
7/21/98 7:00	80	27.32	3.02	2.22	0		0		0			1100	6.11	1100	6.11
7/21/98 8:00	5290	28.57	2.66	2.22	0		2468	4.86	2468	4.86		0		4937	4.86
7/21/98 9:00	1041	28.73	2.33	2.22	0		0		0			1100	6.02	1100	6.02
7/21/98 10:00	2382	28.58	2.22	2.22	0		0		2223	5.03		0		2223	5.03
7/21/98 11:00	2765	28.83	2.43	2.22	0		0		2580	5.06		0		2580	5.06
7/21/98 12:00	6376	29.14	3.30	2.22	0		2975	5.29	2975	5.30		0		5951	5.30
7/21/98 13:00	7873	29.51	3.93	2.22	0		3674	3.91	3674	3.91		0		7348	3.91
7/21/98 14:00	9263	29.61	4.36	2.22	2882	3.48	2882	5.02	2882	5.02		0		8645	4.51
7/21/98 15:00	9223	29.56	4.07	2.22	2869	3.49	2869	5.01	2869	5.01		0		8608	4.50
7/21/98 16:00	9213	29.61	4.13	2.22	2866	3.49	2866	5.01	2866	5.01		0		8598	4.50
7/21/98 17:00	9053	29.7	4.30	2.22	2816	3.51	2816	4.96	2816	4.96		0		8449	4.47
7/21/98 18:00	8652	29.8	4.12	2.22	2692	3.55	2692	4.83	2692	4.84		0		8075	4.41
7/21/98 19:00	9105	29.82	4.03	2.22	2832	3.50	2832	4.97	2832	4.97		0		8497	4.48
7/21/98 20:00	9098	29.84	4.08	2.22	2830	3.50	2830	4.97	2830	4.97		0		8491	4.48
7/21/98 21:00	9121	29.74	3.89	2.22	2837	3.50	2837	4.97	2837	4.98		0		8512	4.48
7/21/98 22:00	4938	29.61	3.83	2.22	0		2304	4.82	2304	4.82		0		4608	4.82
7/21/98 23:00	80	29	2.46	2.22	0		0		0			1100	6.01	1100	6.01
												Daily Average DO =		5.16	

**TABLE 6**  
**DISCRETE BUBBLE MODEL APPLICATION TO PREDICT FUTURE STATION**  
**TAILRACE DISSOLVED OXYGEN: EXAMPLE OF FLOW ALLOCATION TO THE**  
**WYLIE DEVELOPMENT ON A DAY WITH LIMITED GENERATION AND LOW**  
**INFLOW DISSOLVED OXYGEN USING THE FLOW-WEIGHTED AVERAGE**  
**DISSOLVED OXYGEN VALUE**

Date / Time	Historical Flows				Future CRA Flows									
				All Units	Unit 1		Unit 2		Unit 3		Unit 4		Station	
	Station (cfs)	Station Temp (°C)	Station DO (mg/l)	Inflow DO [flow avg method] (mg/l)	Turbine Flow (cfs)	DBM Tailrace DO (mg/l)	Turbine Flow (cfs)	DBM Tailrace DO (mg/l)	Turbine Flow (cfs)	DBM Tailrace DO (mg/l)	Turbine Flow (cfs)	DBM Tailrace DO (mg/l)	Total Generation Flow (cfs)	Tailrace Hourly DO (mg/l)
7/15/98 0:00	139	28.06	2.08	3.32	0		0		0		1100	6.67	1100	6.67
7/15/98 1:00	80	27.55	2.23	3.32	0		0		0		1100	6.70	1100	6.70
7/15/98 2:00	80	27.43	2.29	3.32	0		0		0		1100	6.71	1100	6.71
7/15/98 3:00	80	27.19	2.44	3.32	0		0		0		1100	6.72	1100	6.72
7/15/98 4:00	80	26.95	2.37	3.32	0		0		0		1100	6.74	1100	6.74
7/15/98 5:00	1996	27.62	2.23	3.32	0		0		0		1408	6.69	1408	6.69
7/15/98 6:00	382	27.96	1.76	3.32	0		0		0		1100	6.68	1100	6.68
7/15/98 7:00	80	27.75	1.74	3.32	0		0		0		1100	6.69	1100	6.69
7/15/98 8:00	373	27.51	2.05	3.32	0		0		0		1100	6.70	1100	6.70
7/15/98 9:00	2147	27.95	2.25	3.32	0		0		0		1514	6.67	1514	6.67
7/15/98 10:00	199	28.23	2.01	3.32	0		0		0		1100	6.66	1100	6.66
7/15/98 11:00	2416	28.23	2.62	3.32	0		0		1704	6.42	0		1704	6.42
7/15/98 12:00	1033	28.38	2.51	3.32	0		0		0		1100	6.65	1100	6.65
7/15/98 13:00	1993	28.32	2.65	3.32	0		0		0		1406	6.65	1406	6.65
7/15/98 14:00	4111	28.6	3.57	3.32	0		0		2900	6.12	0		2900	6.12
7/15/98 15:00	5886	28.98	4.13	3.32	0		2076	5.82	2076	5.82	0		4152	5.82
7/15/98 16:00	5894	29	4.07	3.32	0		2079	5.82	2079	5.82	0		4157	5.82
7/15/98 17:00	5889	28.95	4.07	3.32	0		2077	5.82	2077	5.82	0		4154	5.82
7/15/98 18:00	3459	28.63	3.18	3.32	0		0		2440	5.72	0		2440	5.72
7/15/98 19:00	2490	28.4	2.66	3.32	0		0		1756	6.37	0		1756	6.37
7/15/98 20:00	2292	28.37	2.58	3.32	0		0		0		1617	6.65	1617	6.65
7/15/98 21:00	190	28.32	2.06	3.32	0		0		0		1100	6.65	1100	6.65
7/15/98 22:00	80	28.18	1.90	3.32	0		0		0		1100	6.66	1100	6.66
7/15/98 23:00	138	27.48	2.22	3.32	0		0		0		1100	6.71	1100	6.71
Daily Average DO =														6.49

**TABLE 7**  
**DISCRETE BUBBLE MODEL APPLICATION TO PREDICT FUTURE STATION**  
**TAILRACE DISSOLVED OXYGEN: EXAMPLE OF FLOW ALLOCATION TO THE**  
**WYLIE DEVELOPMENT ON A DAY WITH SIGNIFICANT GENERATION AND LOW**  
**INFLOW DISSOLVED OXYGEN USING THE FLOW-WEIGHTED AVERAGE**  
**DISSOLVED OXYGEN VALUE**

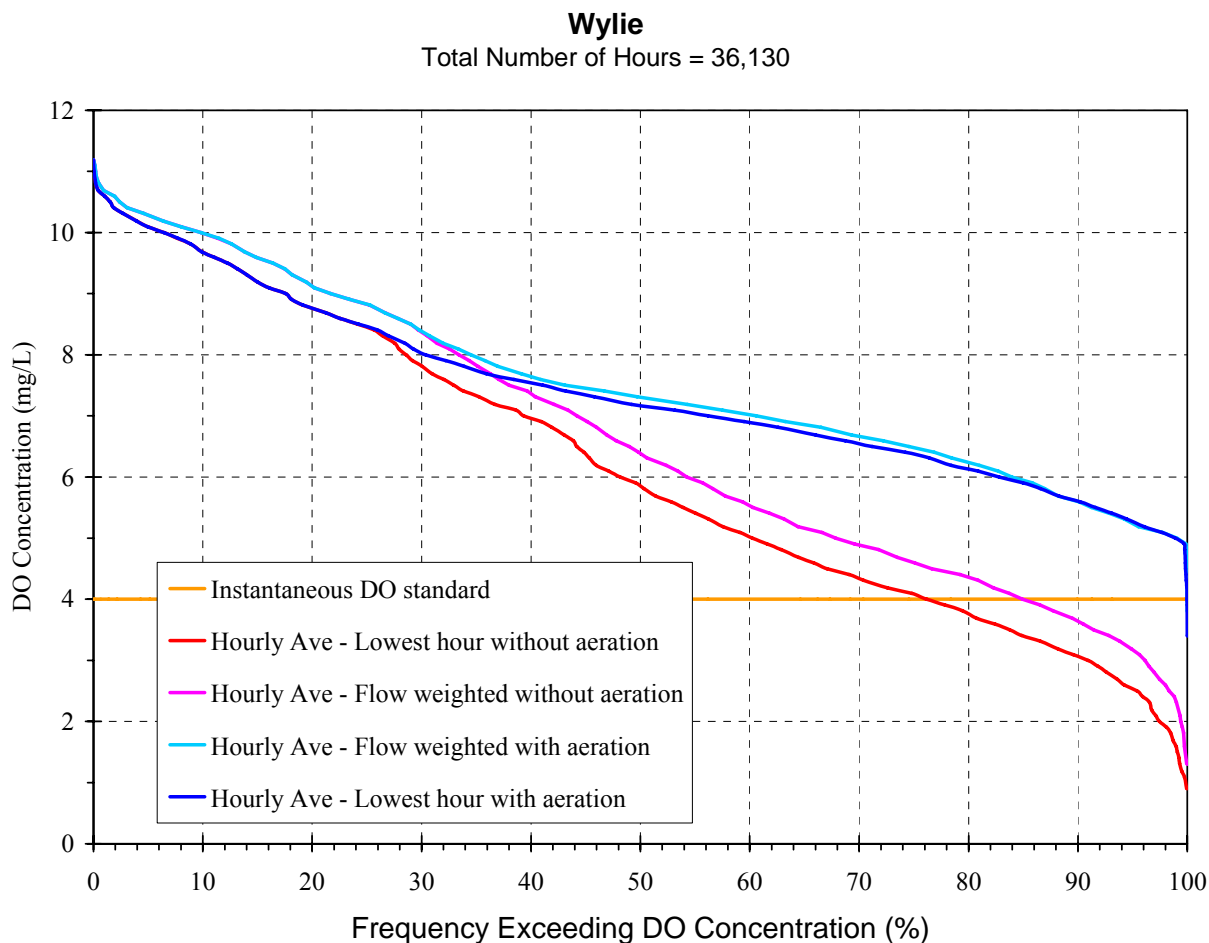
Date / Time	Historical Flows				Future CRA Flows									
				All Units	Unit 1		Unit 2		Unit 3		Unit 4		Station	
	Station (cfs)	Station Temp (°C)	Station DO (mg/l)	Inflow DO [flow avg method] (mg/l)	Turbine Flow (cfs)	DBM Tailrace DO (mg/l)	Turbine Flow (cfs)	DBM Tailrace DO (mg/l)	Turbine Flow (cfs)	DBM Tailrace DO (mg/l)	Turbine Flow (cfs)	DBM Tailrace DO (mg/l)	Total Generation Flow (cfs)	Tailrace Hourly DO (mg/l)
7/21/98 0:00	2132	28.72	2.82	3.81	0		0		1990	6.35	0		1990	6.35
7/21/98 1:00	3395	28.62	3.14	3.81	0		0		3168	6.40	0		3168	6.40
7/21/98 2:00	80	28.6	2.60	3.81	0		0		0		1100	6.91	1100	6.91
7/21/98 3:00	80	28.4	2.71	3.81	0		0		0		1100	6.92	1100	6.92
7/21/98 4:00	80	28	3.02	3.81	0		0		0		1100	6.94	1100	6.94
7/21/98 5:00	80	27.7	3.14	3.81	0		0		0		1100	6.96	1100	6.96
7/21/98 6:00	80	27.5	3.18	3.81	0		0		0		1100	6.98	1100	6.98
7/21/98 7:00	80	27.32	3.02	3.81	0		0		0		1100	6.99	1100	6.99
7/21/98 8:00	5290	28.57	2.66	3.81	0		2468	5.97	2468	5.98	0		4937	5.97
7/21/98 9:00	1041	28.73	2.33	3.81	0		0		0		1100	6.90	1100	6.90
7/21/98 10:00	2382	28.58	2.22	3.81	0		0		2223	6.102	0		2223	6.10
7/21/98 11:00	2765	28.83	2.43	3.81	0		0		2580	6.125	0		2580	6.13
7/21/98 12:00	6376	29.14	3.30	3.81	0		2975	6.33	2975	6.33	0		5951	6.33
7/21/98 13:00	7873	29.51	3.93	3.81	0		3674	5.19	3674	5.19	0		7348	5.19
7/21/98 14:00	9263	29.61	4.36	3.81	2882	4.85	2882	6.11	2882	6.118	0		8645	5.70
7/21/98 15:00	9223	29.56	4.07	3.81	2869	4.86	2869	6.11	2869	6.111	0		8608	5.69
7/21/98 16:00	9213	29.61	4.13	3.81	2866	4.86	2866	6.10	2866	6.107	0		8598	5.69
7/21/98 17:00	9053	29.7	4.30	3.81	2816	4.87	2816	6.06	2816	6.065	0		8449	5.67
7/21/98 18:00	8652	29.8	4.12	3.81	2692	4.91	2692	5.96	2692	5.961	0		8075	5.61
7/21/98 19:00	9105	29.82	4.03	3.81	2832	4.87	2832	6.07	2832	6.073	0		8497	5.67
7/21/98 20:00	9098	29.84	4.08	3.81	2830	4.87	2830	6.07	2830	6.071	0		8491	5.67
7/21/98 21:00	9121	29.74	3.89	3.81	2837	4.86	2837	6.08	2837	6.08	0		8512	5.67
7/21/98 22:00	4938	29.61	3.83	3.81	0		2304	5.94	2304	5.94	0		4608	5.94
7/21/98 23:00	80	29	2.46	3.81	0		0		0		1100	6.88	1100	6.88
											Daily Average DO =		6.21	

For each Project development in South Carolina, starting at Wylie and ending at Wateree, this report presents four statistical summary charts showing hourly and daily average DO concentrations from unaerated and aerated turbine generation. Using the method presented in Tables 4 through 7, (using actual flow and DO measurements at all stations other than Wylie and Wateree) the entire record of historical monitoring data were used at each hydro to calculate the frequency of occurrence of all hourly DO values (both historical and predicted values) at 0.1 mg/l intervals.

The first type of statistical summary chart is a percent exceedance chart showing the cumulative frequency of hourly DO concentrations. The next chart presents the number of hours from the entire monitoring period that do not meet state DO standards. These calculations and charts are repeated for the daily average DO concentrations with and without aeration. All charts show DO concentration statistics for the turbines without aeration, and show DO concentration

statistics with proposed turbine aeration modifications and operational improvements fully implemented. These four statistical summary charts are presented along with a development-specific discussion including any additional information that may be useful in assessing the development's capability to meet or exceed state DO concentration standards after implementation of proposed CRA improvements.

**FIGURE 11**  
**FREQUENCY OF COMPLIANCE WITH STATE WATER QUALITY STANDARDS**  
**FOR HOURLY DISSOLVED OXYGEN AT THE WYLIE DEVELOPMENT -**  
**CALCULATED FROM THE DISCRETE BUBBLE MODEL USING CRA MINIMUM**  
**FLOWS**



#### 4.2.6 Conservative Assumptions of Applying the Dynamic Bubble Model to Predict Future Compliance with Water Quality Standards

The prediction of future tailrace DO concentrations at the Project employ numerous factors. Factors involving the data and application of the DBM which lead to conservatisms in the prediction of tailrace DO include:

- DO Sensor Fouling
- Projection of future Reservoir DO levels
- Operational considerations
- Additional sources of aeration

##### **DO Sensor Fouling**

The standard Clark Cell used to measure tailrace DO was very prone to fouling. Organic slime, inorganic accumulations, membrane hysteresis, etc. would change the integrity of the Teflon membrane, changing the calibration of the sensor. Even though the instruments were replaced, cleaned, and calibrated approximately every 2 weeks, with more frequent maintenance during the summer months, the sensors would lose their calibration. The average fouling rates (Table 8) at each hydro provide an estimate of the error of the long-term measurements. Unlike the method used by the USGS (Wagner et al. 1999), the historical continuous DO data were not “corrected” for instrument calibration errors. These data imply that, on the average, the historical DO concentrations and, consequently, the calculated DO uptake from the DBM, would typically yield underestimates of the actual DO values by 0.55 mg/l (range of 0.32–0.88 mg/l).

**TABLE 8**  
**AVERAGE DISSOLVED OXYGEN SENSOR FOULING RATES**

<b>Development</b>	<b>Average Fouling Rate (mg/l per deployment)</b>	<b>Average Deployment Time (days)</b>
Bridgewater	-0.32	14.9
Rhodhiss	-0.72	14.8
Oxford	-0.81	14.4
Lookout Shoals	-0.48	14.6
Cowans Ford	-0.51	14.3
Mountain Island	-0.37	14.1
Wylie	-0.62	12.9
Fishing Creek	-0.23	12.8
Great Falls-Dearborn	-0.51	12.2
Rocky Creek-Cedar Creek	-0.66	12.3
Wateree	-0.88	12.8

### **Projection of Future Reservoir DO Levels**

The application of the DBM to data recorded since 1996 to predict future DO levels implies that the DO concentration in the water supplying the turbines would be of similar concentrations in the future (for the term of the New License). However, with the state water quality agencies and various groups actively pursuing various initiatives to improve water quality (e.g., Charlotte Mecklenburg Utilities agreement with SCDHEC to reduce nutrient input to Fishing Creek Reservoir), the DO in the reservoirs is not expected to decline, but rather DO is expected to increase as nutrient loading is reduced to the lakes as TMDLs are implemented and completed.

### **Operational Considerations**

The first step in the application of the DBM to historic data was the allocation of historic flows to the various units at each hydro. A computer program allocated the flows to each unit based upon that unit's range of operations. For example, if the historical project flow exceeded the flow of an individual unit, the excess flow would be routed through another unit to calculate the predicted tailrace DO. However, operators can make decisions to utilize the most efficient aerating units and re-balance unit flows to the levels yielding the most effective aerating results. Instead of an automatic flow allocation, an operator may adjust the flow as necessary to comply with state standards, thereby optimizing the power output and water quality compliance.

Choices made by operators to adjust unit flows were not considered in the use of the DBM to predict future tailrace DO levels.

### **Additional Sources of Aeration**

Additional sources of DO may be provided by natural aeration in the bypassed reaches and by the higher natural aeration of minimum flows compared to generation flows (increased surface to volume ratio of the minimum flows). These processes, as with fouling rates, were totally ignored in estimating future DO levels and provide additional conservatism to the DBM predictions.

Also ignored in the tailwater DO estimates was the additional aeration provided by combined unit flow. Units with high aeration capacity adjacent to units with lower aeration efficiency would tend to add additional oxygen to the mixed flow. Throughout the turbine testing, DO levels in combined flows of high and low aerating units were observed to be greater than the flow-weighted average of individual flows.

## **4.3 Assessment of Operating Scenarios**

Water quality modeling conducted after an operational scenario was agreed upon by stakeholders enabled a relative comparison of whether proposed future CRA operations may be expected to have an enhancing, degrading, or neutral influence on various reservoir parameters. This assessment supplements the required tailwater water quality certification assessments by examining parameters that are not directly addressed by water quality standards and existing uses in the hydro station tailraces and riverine sections.

NCDWQ and SCDHEC realize that changes in the flow regime at Project developments as a result of the implementation of the CRA could potentially impact water quality within a reservoir and/or in the downstream riverine reach. Since actual, long-term test demonstrations and subsequent water quality measurements were impractical, computer models (U.S. Army Corps of Engineers [USACOE] CE-QUAL-W2 model) were developed and calibrated for most Project reservoirs. These calibrated computer models were then used to evaluate the water quality of the Project waters by applying the CRA operating provisions to a “normal”, “high flow”, and “dry”

year. The specific daily flows produced by the CHEOPS model were used in the specific CE-QUAL-W2 model to predict the reservoir water quality under the New License operating provisions that would be expected in the various flow years. The results of the computer modeling were compared for current operation and future operation. The Water Quality Resource Committee defined the issues within each reservoir for comparison. For example, walleye habitat was an important issue in Lake James because temperature and DO define the quantity of this species' habitat in the lake. The volume of habitat was compared between current day operations and future CRA operations.

Section 7.2 (Assessments of Operational Scenarios) of this application explains this modeling in more detail, including the metrics considered and the results of current day operations compared to operations under the CRA.

#### **4.4 Quality Assurance Project Plan**

Appendix A of this SIP presents a detailed description of the QAPP that is proposed for the Project.

## **Section 5**

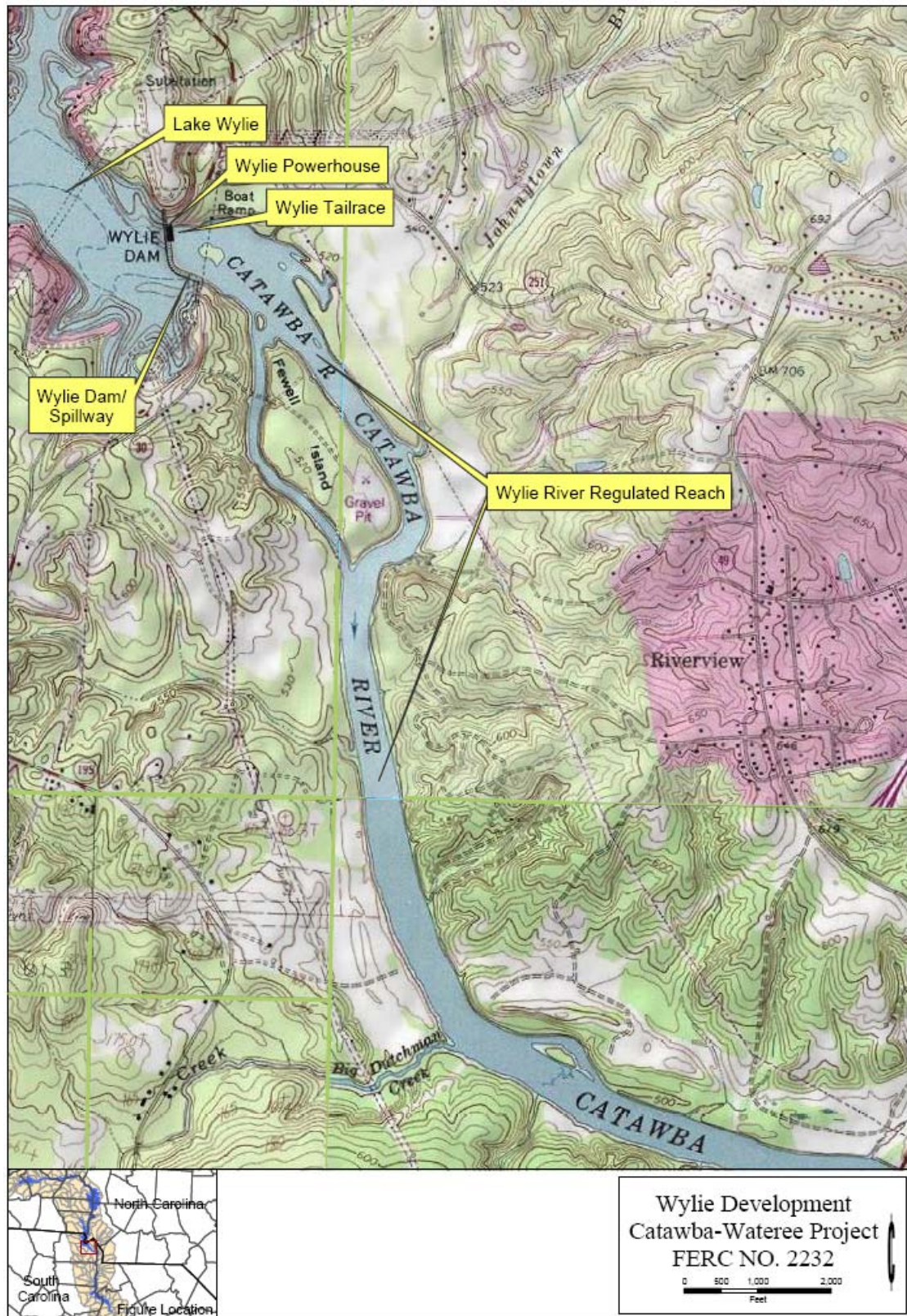
# **Water Quality Assessment and Improvements – Individual Developments**

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## **5.1 Wylie Development**

The Wylie Development consists of the following existing facilities: (1) the Wylie Dam consisting of: (a) a 234-foot-long bulkhead; (b) a 790.92-foot-long ogee spillway section that contains 2 controlled sections with a total of 11 Stoney gates, each 45-feet-wide by 30-feet-high, separated by an uncontrolled section with no gates; (c) a 400.92-foot-long bulkhead; and (d) a 1,595-foot-long earth embankment; (2) a 12,177-acre reservoir with a normal water surface elevation of 569.4 feet above msl; (3) a powerhouse integral to the dam, situated between the bulkhead and the spillway near the left bank, containing four vertical Francis-type turbines directly connected to four generators rated at 18,000 kW for a total installed capacity of 69 MW; and (4) other appurtenances (Figure 12).

**FIGURE 12**  
**WYLIE DEVELOPMENT**



### 5.1.1 Current Status

#### 5.1.1.1 South Carolina DHEC Assessments and Water Quality Standards

Ambient monitoring indicates that at most sites recreational and aquatic life are fully supported; however, fecal coliforms and copper levels periodically impact the use at specific locations in the lake. Generally, pH levels are decreasing, phosphorus and nitrogen levels are also reported to be decreasing. The report states that DO levels in the forebay region also appear to be decreasing. Turbidity levels fluctuate at various locations within the reservoir.

Impaired waters inside the project boundaries:

- Mill Creek Arm of Lake Wylie: aquatic life impairment, copper levels

Impaired waters outside the project boundaries that potentially influence water quality within the project include:

- South Carolina 303(d) listings for inflows to Lake Wylie were:
  - Crowders Creek watershed: 5 locations, recreation and aquatic life impairment, (fecal coliforms, turbidity, biological assessment)
  - Allison Creek watershed: 1 location, recreation (fecal coliform)

#### 5.1.1.2 FERC Relicensing Data Summary

### **Reservoir - Lake Wylie**

#### Water Quality Findings

- Lake Wylie has a moderate retention time (39 days on average). Most of the flow entering Lake Wylie comes from the Mountain Island Development and South Fork Catawba River.
- Duke Energy operates the Wylie Development for peaking energy, maintenance of target lake levels, and downstream water use. In addition, Allen Steam Station withdraws cooling

- water from the Catawba River arm (downstream from the Mountain Island Development) and discharges the heated water to the South Fork arm.
- Overall according to NCDWQ, water quality is considered impaired in the North Carolina portion of the reservoir due to nutrient levels. South Carolina does not currently consider the reservoir impaired for nutrients. North Carolina and South Carolina have different water quality assessment methodologies, monitoring requirements and criteria.
  - The water quality in the discharges from Mountain Island is very good. Nutrients in the South Fork Catawba River are elevated primarily due to point sources from WWTPs.
  - Heated, low nutrient water withdrawn by Allen Steam Station rises to the surface of the South Fork Catawba arm of the reservoir and usually causes the high nutrients from the South Fork Catawba to enter the remainder of Wylie Reservoir as an interflow below the warmer surface layer. The interflow of South Fork water limits the availability of nutrients to algae growing in the surface layers.
  - Wylie Reservoir also receives elevated levels of phosphorus from Crowders Creek.
  - Due to the highly variable water withdrawal zones of the Wylie Development, coupled with the influence of Allen Steam Station, water currents in Wylie are dynamic and thermal stratification is weak and transient.

### Biological Resource Findings

The following information on the biological resources of Lake Wylie was provided in Book 2 of 10, Application for New License Supplement and Clarification - Aquatics 01 Study Report (Duke Energy 2007):

- Thirty-eight species of fish, plus hybrid sunfish, were observed during spring littoral zone electrofishing on Lake Wylie (1993-1997; 1999-2002). Three areas were sampled: an uplake region near Plant Allen, in the South Fork Catawba arm of Lake Wylie just above the confluence with the main Catawba River channel; a midlake region in the vicinity of Buster Boyd Bridge; and a downlake region in major coves on both sides of the main channel, in the vicinity of Catawba Nuclear Station.

- Total littoral fish biomass averaged 132.0 kilograms per kilometer of shoreline in the uplake area, 122.8 kg/km midlake, and 88.7 kg/km downlake. According to total biomass, the littoral fish community in the uplake area consisted of, on average, 38 percent largemouth bass, 19 percent common carp, 16 percent white catfish, and 8 percent bluegill. In the midlake area, biomass was comprised of 47 percent largemouth bass, 20 percent white catfish, 9 percent bluegill, and 8 percent gizzard shad. The downlake area was generally similar to that observed midlake, consisting of 41 percent largemouth bass, 23 percent white catfish, 11 percent bluegill, and 11 percent gizzard shad.
- In terms of numbers, sunfish accounted for 64 to 65 percent of total fish density lakewide, while largemouth bass accounted for 11 to 14 percent.
- Hydroacoustic sampling on Lake Wylie (1997 and 2000) indicated that mean densities of limnetic forage fish ranged from 2,402 fish/ha in the South Fork Catawba arm to 8,746 fish/ha downlake.
- Annual purse seine samples (1993-2003, excluding 1998) indicated that the taxonomic composition of the forage fish community was greater than 99 percent threadfin shad. Alewife first appeared in Lake Wylie in 2001, presumably due to downstream transport of this species from Mountain Island Lake; however, alewife comprised less than 1 percent of the purse seine catch from 2000 through 2003.
- Winter kills of threadfin shad were occasionally reported during the 1970s and 1980s.

### **Wylie Regulated River Reach**

#### **Water Quality Findings**

- Ten years of tailrace continuous monitoring at  $\approx$  5-minute intervals for temperature, pH, and DO revealed that only DO did not meet state water quality standards for turbine releases.
- On the average, during May through November, 29 percent of the hourly average DO concentrations released from the Wylie Development are lower than the current state standard of 4.0 mg/l instantaneous.

- On the average, during May through November, 49 percent of the daily average DO concentrations released from the Wylie Development are lower than the current state standard of 5.0 mg/l daily average.
- Actual 4-year (1997–2000) average nutrient Mountain Island releases compared to Wylie Releases:
  - Phosphorus – Mountain Island = 11 mg/l; Wylie = 33 mg/l
  - Dissolved Organics – Mountain Island = 1.7 mg/l; Wylie = 2.7 mg/l
  - Particulate Organics – Mountain Island = 1.1 mg/l; Wylie = 1.6 mg/l
- The 30-mile river reach from Lake Wylie to Fishing Creek Reservoir is one of the longest free flowing reaches in the Project area. Downstream from Lake Wylie, DO is primarily controlled by Wylie generation. Progressively downstream, aquatic plant growths dominate river DO. Hydro tests indicate that aeration of Wylie’s turbine flow only extends DO enhancements to upstream of Sugar Creek (approximately 10 miles). DO concentrations measured about a mile downstream of the Sugar Creek confluence ranged between 5.9 and 8.5 mg/l, the diel changes of DO corresponded to aquatic plant activity and did not correspond to Wylie operations.

### Biological Resource Findings

The following information on the biological resources of the Wylie Regulated River Reach was provided in Book 2 of 10, Application for New License Supplement and Clarification - Aquatics 01, Aquatics 06, and Aquatics 07 Study Reports (Duke Energy 2007):

- The fish community in the Wylie Regulated River Reach was sampled at six locations. The first location was at RM 143.5, the second location was at RM 141.3, the third location was at RM 136.8, the fourth location was at RM 126.4, the fifth location was at RM 117.8, and the sixth location was at RM 114.4.
- The species composition of the fish community at RM 143.5 was typical for the habitat type present in this reach with 16 fish species and 337 individuals being collected. Redbreast sunfish and bluegill comprised 61 percent of the total number of individuals collected.

- The species composition of the fish community at RM 141.3 was typical for the habitat type present in this reach with 16 fish species and 280 individuals being collected. Spottail shiner and redbreast sunfish comprised 54 percent of the total number of individuals collected.
- The species composition of the fish community at RM 136.8 was typical for the habitat type present in this reach with 14 fish species and 324 individuals being collected. Snail bullhead and redbreast sunfish comprised 57 percent of the total number of individuals collected.
- The species composition of the fish community at RM 126.4 was typical for the habitat type present in this reach with 24 fish species and 201 individuals being collected. Redbreast sunfish and bluegill comprised 61 percent of the total number of individuals collected.
- The species composition of the fish community at RM 117.8 was typical for the habitat type present in this reach with 16 fish species and 203 individuals being collected. Snail bullhead and redbreast sunfish comprised 43 percent of the total number of individuals collected.
- The species composition of the fish community at RM 114.4 was typical for the habitat type present in this reach with 16 fish species and 159 individuals being collected. Redbreast sunfish and bluegill comprised 57 percent of the total number of individuals collected.
- Benthic invertebrate sampling in this reach indicated good populations of macroinvertebrates. Densities of macroinvertebrates were lower 1 kilometer downstream of the Wylie powerhouse (Location 1) as compared to the samples collected 2 kilometers downstream of the Wylie powerhouse (Location 3). The EPT densities were lowest at Location 1 and higher at Location 3. There were no relationships between total densities and distance from the dam in spring or summer.
- Similar trends were found for EPT densities in spring and summer. The bioclassification was Fair at both Wylie Location 1 and Wylie Location 3, although the score at Location 3 was nearly into the Good-Fair range. There were eight EPT taxa collected at Location 1, and ten collected downstream at Location 3; the community at the downstream location was composed of relatively less tolerant organisms than those found near the dam.

- In addition to the fish community discussed above, the Wylie Tailrace and the Wylie Regulated River Reach also provide habitat for populations of the freshwater mussel species: *Elliptio complanata*, *Elliptio icterina*, *Elliptio angustata*, *Elliptio producta*, *Elliptio roanokensis*, *Unio merus* sp., *Utterbackia imbecillis*, *Pyganodon cataracta*, *Strophitus undulatus*, *Ligumia nasuta*, and *Villosa delumbis*. An extensive and robust mussel community was observed at these locations. Other mussel and snail species observed in this area include Asiatic clams (*Corbicula fluminea*) and River horn snail (*Elimia catenaria*).
- Crayfish were also collected from this area incidental to other survey activities. The crayfish species collected in this location includes *Cambarus* (*Cambarus*) *howardi*.

### 5.1.2 Water Quality Issue Identification and Evaluation

Even though the SCDHEC assessment of the Wylie Development waters is deemed compatible with the ascribed designated use, water released into the regulated river reach was not consistently meeting state water quality standards. Therefore, the primary issue dealing with water quality is to protect the water quality where standards were met, and to bring appropriate areas up to state water quality standards.

#### **Wylie Regulated River Reach**

- Increase minimum flow in Catawba River channel.
- Enhance DO concentrations of water released from powerhouse to meet state standards.

### 5.1.3 Project Modifications for Water Quality Compliance and Resource Enhancement

Stakeholder negotiations and engineering evaluations have resulted in proposed structural changes and operational changes.

**Proposed Engineering Changes**

**TABLE 9**  
**WYLIE DEVELOPMENT AERATION CAPABILITIES**

<b>Turbine/ Other Release Point</b>	<b>Original</b>	<b>Current (as of 12/31/2006)</b>	<b>Future (from FWQIP)</b>
Wylie Unit 1	OVB	EVb	EVb
Wylie Unit 2	OVb	HVR	HVR
Wylie Unit 3	OVb	HVR	HVR
Wylie Unit 4	OVb	OVb	AVR CMR

OVb = Original Vacuum Breaker - Unimproved original vacuum breaker aeration

EVb = Enhanced Vacuum Breaker - Improved vacuum breaker aeration (modified piping and/or headcover)

HVR = Hub Venting Runner - Central aeration through runner hub (new hub venting runner)

AVR = Auto Venting Runner - Auto venting type turbine aeration (new auto venting runner)

CMR = Dedicated continuous minimum flow turbine, valve or modification

For additional details, refer to the FWQIP shown in Table 4 of the 401 Water Quality Application.

**Proposed Operational Changes****Reservoir - Lake Wylie**

**TABLE 10**  
**TARGET RESERVOIR ELEVATIONS FOR LAKE WYLIE**

<b>Elevation (ft) at start of day</b>	<b>USGS</b>	<b>Datum</b>	<b>Full Pond = 100</b>	
	Existing	Proposed	Existing	Proposed
January 1	566.5	566.5	97	97
February 1	566.5	566.5	97	97
March 1	566.5	566.5	97	97
April 1	566.5	566.5	97	97
May 1	566.5	566.5	97	97
June 1	566.5	566.5	97	97
July 1	566.5	566.5	97	97
August 1	566.5	566.5	97	97
September 1	566.5	566.5	97	97
October 1	566.5	566.5	97	97
November 1	566.5	566.5	97	97
December 1	566.5	566.5	97	97

- In addition, the reservoir stabilization program for enhancement of largemouth bass spawning will be continued for Lake Wylie.

#### Wylie Regulated River Reach

- Minimum Habitat Continuous Flows - The habitat flows for the Project in the CRA are based on study results, stakeholder negotiations and CHEOPS analysis of flow levels that provided improved aquatic habitat, balanced other water user interests, and which were at levels which could be sustained over the life of the New License.
- A new turbine will be installed at the Wylie Powerhouse that will be able to provide 1,100 cfs continuous minimum flow to the Wylie Regulated River Reach.
- A new high inflow protocol (HIP) will monitor upstream streamflow gages and when above-average streamflows are indicated, the continuous minimum flow will be increased to 1,300 cfs.

**TABLE 11**  
**CONTINUOUS MINIMUM HABITAT FLOWS (CFS) FOR THE**  
**WYLIE DEVELOPMENT**

Month	New License Minimum Flows (CRA)	Existing Minimum Flows
January	1100	Leakage
February	1100	Leakage
March	1100	Leakage
April	1100	Leakage
May	1100	Leakage
June	1100	Leakage
July	1100	Leakage
August	1100	Leakage
September	1100	Leakage
October	1100	Leakage
November	1100	Leakage
December	1100	Leakage

## 5.1.4 Reasonable Assurance of Future Compliance and Resource Enhancement

### 5.1.4.1 Dissolved Oxygen - Numeric Standards

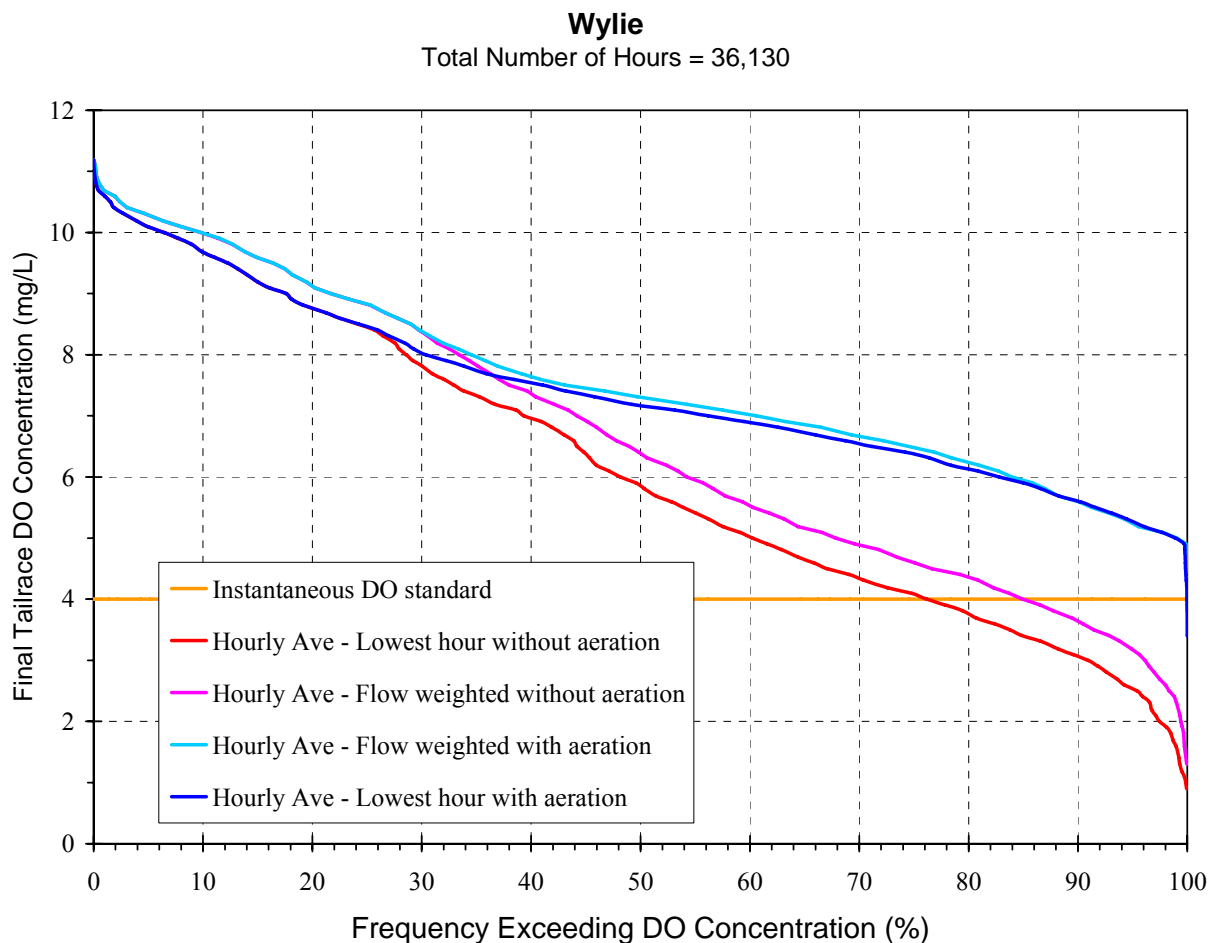
The applicability of turbine venting to the Wylie Development was evaluated by developing a DBM (Appendix C) for each turbine configuration (Wylie = 1 EVB unit, 2 HVR units, and 1 AVR minimum flow unit).

The DBM was calibrated in 2002 for the EVB and one HVR type of turbine. The field calibration test included the following measurements at various unit power levels: air flow, water flow, initial DO flowing to the turbine, temperature, and DO uptake. A DBM was developed for the future minimum flow AVR unit by extrapolating data from other AVR unit specifications and the existing Wylie turbine and draft tube design. The calibrated DBMs for each turbine was used as a tool to predict the DO uptake and future tailrace oxygen conditions by applying the DBM equation to the data from the record of water quality measurements made at 5-minute intervals in the Wylie tailrace.

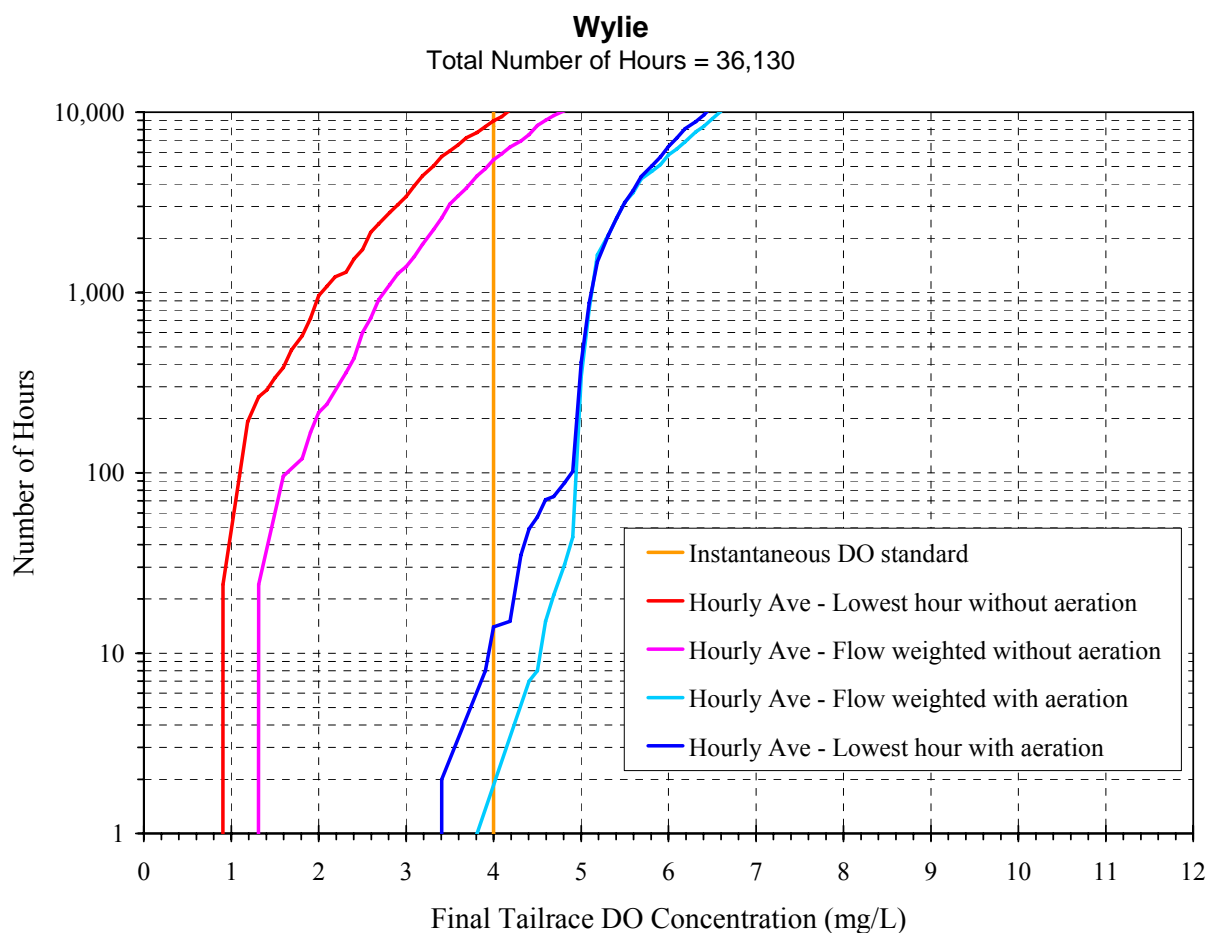
The future AVR unit (Unit 4) will be designed to accommodate the CRA minimum flows as well as aerate the minimum flow under all inflowing DO concentrations to the daily average standard of 5.0 mg/l. However, for the remaining units (Units 1-3), future operations would require flows partitioned between units after the CRA minimum flow was released. This process involved allocating all historical leakage flows to the new minimum flow (1,100 cfs). That amount of water was subtracted from the daily generation and a new daily generation flow was allocated for the DBM flow. Since the DO in the water flowing into the turbines was a function of flow rate and subsequent withdrawal zone, another adjustment to DO is needed in order to compensate for the altered future flow rates. These conservative DO adjustments were (1) the lowest daily DO observed and applied to all flows, and (2) historical daily flow weighted DO. These values were applied to all flows for that day. (See Section 4.2.1 for a complete description of the methodology). These predictions made from the DBM were compared to the actual historical monitoring data.

Of the 36,130 hours used from the historical monitoring data, 76.2 percent of the minimum daily DO values and 84.9 percent of the flow weighted DO concentrations were greater than the instantaneous DO standard of 4.0 mg/l prior to aeration (Figure 13). These percentages corresponded to 624 and 575 total hours, respectively (Figure 14). If the CRA flows would have been in place and the new turbine configuration operable, the DO concentrations in the tailrace would have drastically improved to greater than 99.9 percent compliance with either of the two inflowing DO values (Figure 15). These percentages correspond to 10 hours of non-compliance using the daily minimum DO concentrations and two hours of non-compliance using the flow-weighted average method of assessing inflowing DO. All of these predicted non-compliance values were the result of DBM partitioning high flows with low DO to the various units rather than operating the units specifically for DO compliance.

**FIGURE 13**  
**FREQUENCY OF COMPLIANCE WITH INSTANTANEOUS DISSOLVED OXYGEN**  
**STATE WATER QUALITY STANDARDS (4.0 MG/L) FOR HOURLY DISSOLVED**  
**OXYGEN CONCENTRATIONS AT THE WYLIE DEVELOPMENT – CALCULATED**  
**FROM DISCRETE BUBBLE MODEL IN COMPARISON TO THE HISTORICAL**  
**RECORD**

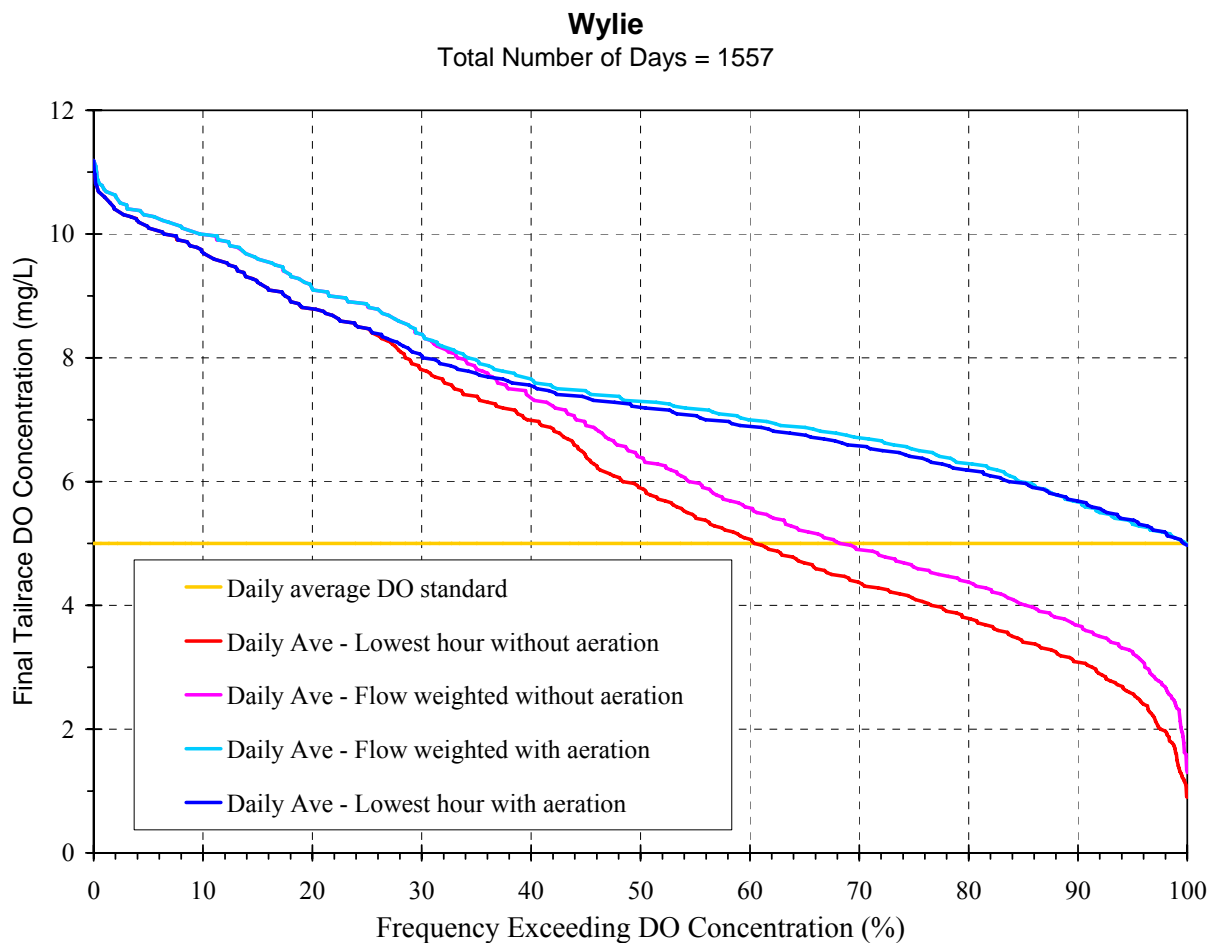


**FIGURE 14**  
**COMPARISON OF HOURS OF NON-COMPLIANCE AT THE WYLIE**  
**DEVELOPMENT TO INSTANTANEOUS DISSOLVED OXYGEN STATE WATER**  
**QUALITY STANDARDS (4.0 MG/L) CALCULATED FROM DISCRETE BUBBLE**  
**MODEL AND THE HISTORICAL RECORD**

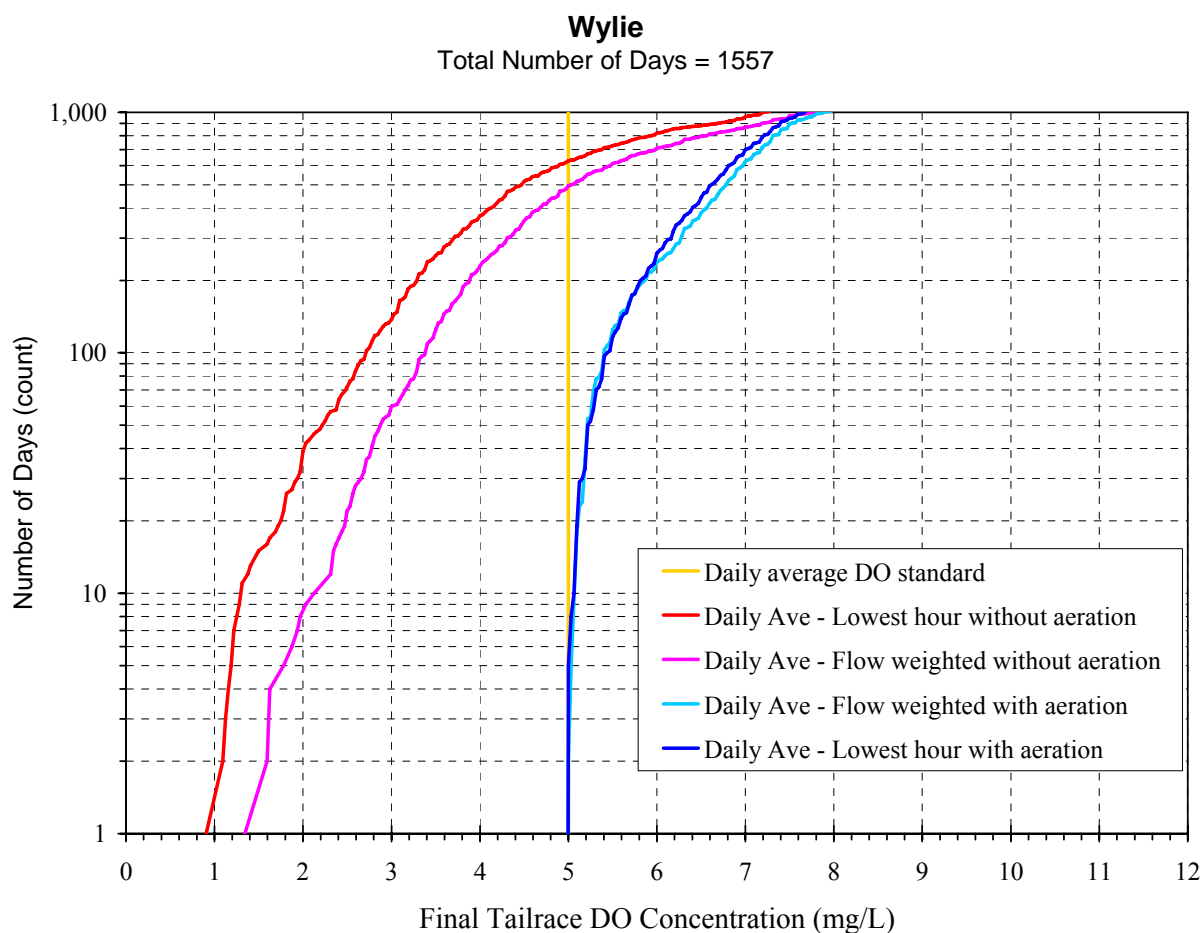


When the daily average DO concentrations were calculated from the hourly DO values, the percentage of compliance with the 5.0 mg/l prior to turbine venting was 61.1 percent for the minimum daily DO method and 69.2 percent for the flow-weighted average method (Figure 15). The total days of non-compliance would have been 618 and 495, respectively (Figure 16). Using the same historical database with 1,557 days of data, but applying the CRA minimum flows and turbine venting, the compliance of the daily average DO standard of 5.0 mg/l would have been 100 percent (Figure 15) with no days exhibiting a daily average of less than 5.0 mg/l (Figure 16).

**FIGURE 15**  
**FREQUENCY OF COMPLIANCE WITH DAILY AVERAGE DISSOLVED OXYGEN**  
**STATE WATER QUALITY STANDARDS (5.0 MG/L) FOR DAILY AVERAGE**  
**DISSOLVED OXYGEN CONCENTRATIONS AT THE WYLIE DEVELOPMENT –**  
**CALCULATED FROM DISCRETE BUBBLE MODEL IN COMPARISON TO THE**  
**HISTORICAL RECORD**



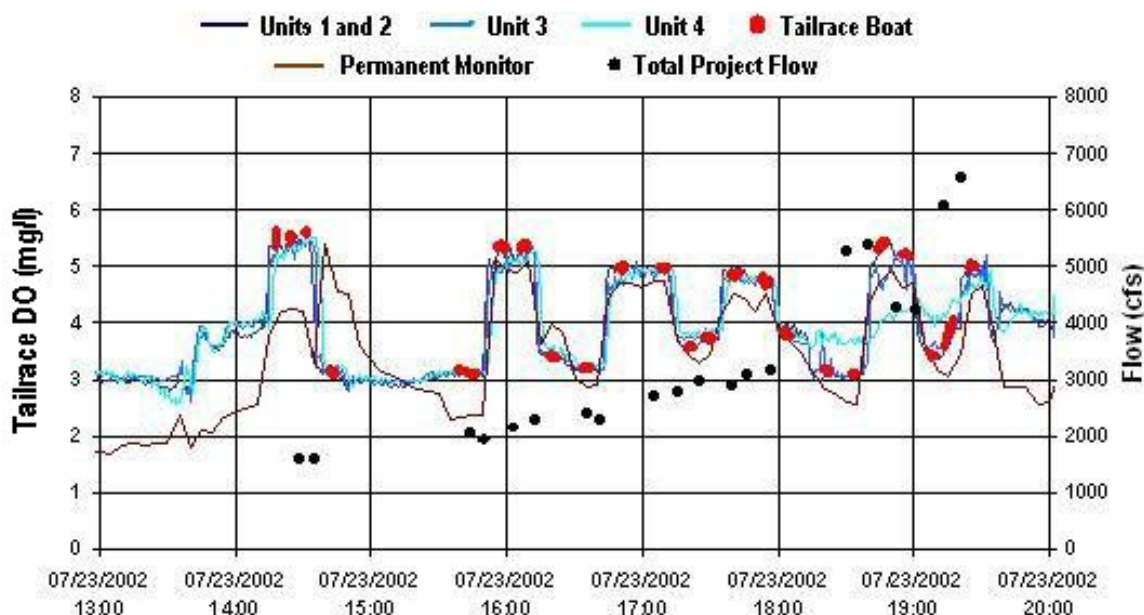
**FIGURE 16**  
**COMPARISON OF DAYS OF NON-COMPLIANCE AT THE WYLIE DEVELOPMENT**  
**TO DAILY AVERAGE DISSOLVED OXYGEN STATE WATER QUALITY**  
**STANDARDS (5.0 MG/L) CALCULATED FROM DISCRETE BUBBLE MODEL AND**  
**THE HISTORICAL RECORD**



The predictions of the resulting turbine aeration with the conditions observed from the long-term monitoring must also be put in perspective due to the monitor placement at the Wylie Development. Unlike the other hydros where the monitor was placed in the main flow of the units, the monitor at Wylie, due to accessibility and power constraints, was placed in a corner where the powerhouse meets the wingwall. The turbine flow at this location was very poor, the area accumulated refuse, responded very slowly to changing tailrace conditions, and generally read lower than other areas of the tailrace, sometimes as much as 1 mg/l (Figure 17). The historical data could not be corrected due to the variability of the differences between other

tailrace readings and the permanent monitor, but, the tendency for the Wylie monitor to underestimate the actual tailrace DO is but one more conservative element in these analysis.

**FIGURE 17**  
**COMPARISON OF THE PERMANENT MONITOR (IN THE CORNER OF THE WINGWALL) DISSOLVED OXYGEN READINGS TO OTHER AREAS IN THE TAILRACE – CONDUCTED DURING TURBINE VENTING TESTS, JULY, 2002**



#### 5.1.4.2 Resource Enhancement – Existing Use Standards

According to the South Carolina Department of Health and Environmental Control (SCDHEC) Regulation 61-68: Water Classifications and Standards for South Carolina Waters (2004): it is the goal of SCDHEC “to maintain and improve all surface waters to a level that provides for the survival and propagation of a balanced indigenous aquatic community of fauna and flora. These narrative criteria are determined by the Department based on the condition of the waters of the State by measurements of physical, chemical, and biological characteristics of the waters according to their classified uses.” This existing use water quality standard addresses the need for any receiving waters to be of suitable quality to provide for appropriate aquatic communities.

As previously described the Wylie Development consists of an impoundment (Lake Wylie) which releases into the regulated river reach downstream. Negotiations with stakeholders indicated that in addition to meeting water quality standards for DO the primary management objectives for the Wylie Development included warmwater fishery and freshwater mussel habitat enhancement.

The allocation of the water resources of the Wylie Development was based on water quality, flow/habitat analyses, and negotiation of releases appropriate for addressing the above resource enhancement goals. These analyses and negotiations lead to the flows for habitat (1,100 cfs continuous).

The minimum continuous releases lead to the following habitat gains in the regulated river reach of the Wylie Development:

**TABLE 12**  
**CRA FLOWS: HABITAT GAINS EXPRESSED AS PERCENTAGE OF UNREGULATED INDEX C FLOWS AT THE**  
**WYLIE REGULATED RIVER REACH\***

Fish Species/Lifestage and/or Guild							
Month	Species/guild: American Shad Spawning	Species/guild: Spider Lily	Species/guild: Golden Redhorse Adult	Species/guild: Deep Fast Adult – Coarse Mixed Substrate (i.e. shorthead redhorse)	Species/guild: Deep Fast Adult – Fine Substrate (i.e. silver redhorse)	Species/guild: Striped Bass Spawning	Species/guild: Deep Fast Spawning – Gravel Cobble Substrate (i.e. white bass)
January	NA	NA	97.4%	76.3%	141.2%	NA	68.3%
February	NA	26.4%	99.0%	76.5%	150.4%	NA	71.0%
March	81.7%	23.0%	103.6%	79.7%	170.3%	NA	83.8%
April	76.6%	26.0%	98.3%	75.8%	151.2%	17.5%	70.3%
May	74.6%	30.6%	94.5%	74.8%	131.5%	21.3%	62.6%
June	NA	NA	95.4%	78.3%	124.1%	27.3%	65.0%
July	NA	NA	92.1%	78.1%	106.9%	NA	58.5%
August	NA	NA	96.1%	83.3%	111.4%	NA	67.0%
September	NA	NA	95.2%	84.1%	107.9%	NA	66.8%
October	NA	NA	98.7%	88.7%	111.3%	NA	74.6%
November	NA	NA	95.0%	80.8%	111.0%	NA	64.1%
December	NA	NA	93.3%	75.0%	122.7%	NA	60.2%

\* Resource Agency goals met; no mitigation required.

Duke has agreed to provide for a 1,100 cfs year-round release unless the HIP is invoked which provides even higher flows. These flows will meet resource agency goals for all species/lifestages except Sturgeon and Striper Spawning. Aquatic habitat for both Sturgeon and Striper Spawning will increase significantly under these flows from the current conditions of <1 percent compared to unregulated habitat to 31 percent and 24 percent, respectively. In addition, Duke will invest millions of dollars to replace an existing unit with a smaller unit sized to operate at the continuous minimum flow. Delivering the continuous minimum flow without pulsing a unit gains an extra 5 miles of suitable river habitat. Therefore, no further mitigation needs were identified. (Reference Section 6 [Flow Mitigation Package] of this SIP.)

Based on CHEOPS analysis and mutual gains negotiations, flows for the Wylie Regulated River Reach were chosen to be 1,100 cfs. This provides considerable habitat gains and proposed continuous minimum flows at Wylie that will be sustainable for the long term.

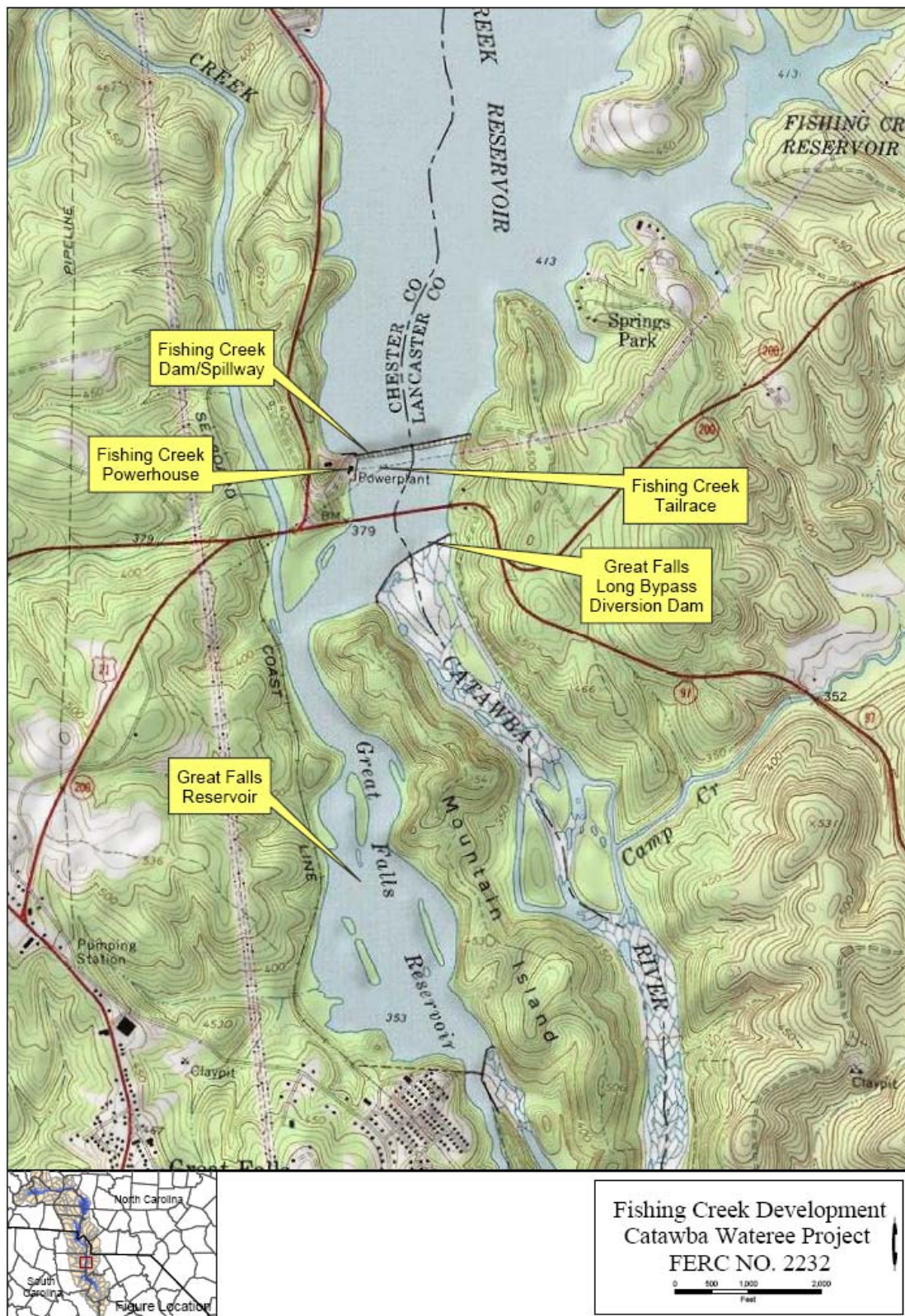
#### 5.1.4.3 Use of Water Quality Modeling to Evaluate Proposed Project Modifications

Please refer to Section 7.2 (Assessments of Operational Scenarios).

## 5.2 Fishing Creek Development

The Fishing Creek Development consists of the following existing facilities: (1) the Fishing Creek Dam consisting of: (a) a 114-foot-long, 97-foot-high uncontrolled concrete ogee spillway; (b) a 1,210-foot-long concrete gravity, ogee spillway with 22 Stoney gates, each 45-feet-wide by 25-feet-high; and (c) a 214-foot-long concrete gravity bulkhead structure; (2) a 3,431-acre reservoir with a normal water surface elevation of 417.2 feet above msl; (3) a powerhouse integral to the dam, situated between the gated spillway and the bulkhead structure near the right bank, containing five vertical Francis-type turbines directly connected to five generators two rated at 10,530 kW and three rated at 9,450 kW for a total installed capacity of 48.1 MW; and (4) other appurtenances (Figure 18).

**FIGURE 18**  
**FISHING CREEK DEVELOPMENT**



## 5.2.1 Current Status

### 5.2.1.1 South Carolina DHEC Assessments and Water Quality Standards

As the Catawba River leaves Lake Wylie, SCDHEC (2005) has observed decreasing trends in pH, turbidity, total phosphorus and total nitrogen. This trend suggests improving water quality conditions downstream of Lake Wylie; however, fecal coliforms prevent fully supporting recreational uses.

Further downstream (Highway 5 bridge), turbidity is increasing and copper levels are greater than state standards. Just prior to entering Fishing Creek reservoir (Highway 9 bridge), total phosphorus concentrations are increasing while BOD levels are decreasing.

Fishing Creek reservoir data suggests increasing levels of turbidity, total phosphorus, and total nitrogen while pH and BOD values are reported to be decreasing. Chlorophyll a levels in the reservoir are periodically high possibly due to high excursions of total phosphorus and increasing levels of total nitrogen. A significant increasing trend in DO concentrations are reported while pH is decreasing. Within the reservoir, recreational use is impaired in the middle of the reservoir while aquatic life is impaired throughout the lake.

Impaired waters inside the project boundaries

- Fishing Creek Reservoir: 3 locations, recreational and aquatic life impairment (total phosphorus, turbidity, and Chlorophyll a)

Impaired waters outside the project boundaries that potentially influence water quality within the project include:

- South Carolina 303(d) listings for inflows to Fishing Creek Reservoir were:
  - Sugar Creek watershed: 7 locations, recreation and aquatic life impairment, (fecal coliforms, copper, biological assessment)

- Twelve Mile Creek watershed: 2 locations, recreation and aquatic life (fecal coliforms, copper, and turbidity)
- Waxhaw Creek watershed: 1 location, recreation and aquatic life (fecal coliforms, and copper)
- Cane Creek watershed: 7 locations, recreation and aquatic life (fecal coliforms, DO, and biological assessment)

North Carolina 303(d) listings for inflows to Fishing Creek Reservoir were:

- 33.1 miles of Sugar Creek watershed (including tributaries): aquatic life impairment
- 8.8 miles of Twelve Mile Creek watershed tributaries: aquatic life impairment

Since the summer of 2001, SCDHEC, NCDWQ, and CMUD have been working towards achieving consensus on an appropriate phosphorus limit for the McAlpine Creek WWTP. The parties are on schedule with actions necessary to complete the terms of the settlement agreement. The final agreement includes four main points: phosphorus limits at all three CMUD facilities, a bubble limit, a mass cap (i.e., maximum that goes into the system), and a TMDL.

- To reduce TP in the watershed, CMUD has agreed to:
  - A permitted TP load from the McAlpine Creek WWTP that is about 50 percent less (on a 12-month rolling average basis) than current actual TP daily loads and about zero percent less (i.e., no change) during peak “mass cap” months (which can occur consecutively as long as the 12-month target is met). Since this WWTP currently has an average discharge of about 42 MGD instead of the permitted discharge level of 64 MGD and if they achieve the target TP concentration level of 1 mg/l is achieved, the immediate TP reduction would be ~ 67 percent from the current TP load.
  - Reduce current combined TP loads from McAlpine, Irvin, and Sugar Creek WWTPs by approximately 43 percent to 57 percent and less than zero percent (i.e., allow more than current daily average loads) during peak “mass cap” months. (Note: the two values given for percent reductions depend on the value of the “current” load

from the Sugar Creek WWTP, whether the baseline is prior to June 2001 or starting in June 2001—TP was significantly reduced in their discharges in June 2001.)

- These TP limits are based on achieving a limit of 1 mg/l total phosphorus in the permitted discharges from these CMUD WWTPs.
- Other actions are being studied to optimize reduction of TP discharges.
- SCDHEC is requiring municipal and industrial wastewater treatment plants in SC to limit the TP concentrations in their discharges to 1 mg/l. In addition, a TMDL for TP for Fishing Creek and Fishing Creek reservoir is being developed by SCDHEC.

#### 5.2.1.2 FERC Relicensing Data Summary

##### **Reservoir – Fishing Creek Lake**

##### **Water Quality Findings**

- Fishing Creek Reservoir has a very short retention time (6 days on average). With minimum storage capability, Fishing Creek Reservoir is dynamic and at most times, inflow driven. Stratification is weak.
- Duke Energy operates the Fishing Creek Development for peaking energy or to maintain target lake levels.
- Stratification is weak to moderate but stable for the most part. Longer residence times occur at the surface and near the bottom in the downstream half of the reservoir. Longest residence times occur in the downstream third of the reservoir near the bottom.
- Fishing Creek Reservoir receives high concentrations of nutrients and organic matter from the watershed downstream from Wylie Dam as well as some elevated phosphorus concentrations in the discharges from Wylie.
- Total phosphorus in the inflows to Fishing Creek is 3 to 4 times greater than the SCDHEC water quality standard and 6 to 7 times greater than the TP level in the Wylie releases. Much of this increase is related to municipal wastewater discharges into Sugar Creek which enters the Catawba River upstream of Fishing Creek Reservoir. In addition, Tufford's (2003) assessment of TP in the watershed between Wylie and the inflow to

Fishing Creek indicated that additional non-point sources controls were needed to reduce the phosphorous into the lower reservoirs (Fishing Creek Reservoir and Lake Wateree).

- Pollutant loads are causing high algae concentrations, producing even more organic matter, and low DO in Fishing Creek Reservoir.
- Fishing Creek Reservoir traps about 15 percent of the TP entering the reservoir through sedimentation and biological processing.
- Algae concentrations in the lake sometimes exceed 100 ug Chlorophyll a/l, which is greater than the SCDHEC standard of 40 ug Chlorophyll a/l.
- BOD5 values (i.e., the biochemical oxygen demand of wastewater during decomposition occurring over a 5-day period) in the river upstream from Fishing Creek reservoir are 2 to 3 times normal levels.
- The short residence time in Fishing Creek Lake prevents wide ranging and frequent episodes of low DO at the surface of the lake. Periodically, 1.4 miles of the reservoir can exhibit less than 5.0 mg/l DO at the surface (12 percent of the reservoir area). Concentrations of DO less than 3 mg/l do not occur at the surface of the lake.

### Biological Resource Findings

The following information on the biological resources of Fishing Creek Lake was provided in Book 2 of 10, Application for New License Supplement and Clarification - Aquatics 01 Study Report (Duke Energy 2007):

- A total of 32 species of fish, plus hybrid sunfish, were observed in Fishing Creek Lake in spring shoreline electrofishing sampling (1993–1999; 2000). In these samples total biomass averaged 92.7 kilogram per kilometer of shoreline, consisting of 37 percent largemouth bass, 30 percent common carp, 11 percent catfish (primarily white and channel catfish), and 10 percent sunfish (primarily bluegill).
- In terms of numbers, the Fishing Creek Lake fish community was dominated by sunfish, which accounted for 53 percent of total fish density, on average; largemouth bass accounted for 15 percent of total density, and gizzard shad 12 percent.

- Hydroacoustic sampling (1997, 2000) indicated that densities of limnetic forage fish densities were estimated to be 3,163 fish per hectare in 1997 and 32,606 fish per hectare in 2000. Species composition of the forage fish community was not examined.
- No fish kills were documented on Fishing Creek Reservoir from 1973 to 2001.

### **Tailrace – Fishing Creek**

#### **Water Quality Findings**

- Ten years of tailrace continuous monitoring at  $\approx$  5-minute intervals for temperature, pH, and DO revealed that only DO did not meet state water quality standards for turbine releases.
- On the average, during May through November, 13 percent of the hourly average DO concentrations released from the Fishing Creek Development are lower than the current state standard of 4.0 mg/l instantaneous.
- On the average, during May through November, 31 percent of the daily average DO concentrations released from the Fishing Creek Development are lower than the current state standard of 5.0 mg/l daily average.
- Actual 4-year (1997–2000) average nutrient Wylie releases compared to Fishing Creek Releases:
  - Phosphorus – Wylie = 33 mg/l; Fishing Creek = 221 mg/l
  - Dissolved Organics – Wylie = 2.7 mg/l; Fishing Creek = 5.9mg/l
  - Particulate Organics – Wylie = 1.6 mg/l; Fishing Creek = 9.3 mg/l

## 5.2.2 Water Quality Issue Identification and Evaluation

### **Fishing Creek Tailrace**

- Enhance DO concentrations of water released from powerhouse to meet state standards.

### 5.2.3 Project Modifications for Water Quality Compliance and Resource Enhancement

Stakeholder negotiations and engineering evaluations have resulted in proposed structural changes and operational changes.

#### **Proposed Engineering Changes**

**TABLE 13**  
**FISHING CREEK DEVELOPMENT AERATION CAPABILITIES**

<b>Turbine / Other Release Point</b>	<b>Original</b>	<b>Current (as of 12/31/2006)</b>	<b>Future (from FWQIP)</b>
Fishing Creek Unit 1	OVb	HSV	HSV
Fishing Creek Unit 2	OVb	HSV	HSV
Fishing Creek Unit 3	OVb	HVR	HVR
Fishing Creek Unit 4	OVb	OVb	OVb
Fishing Creek Unit 5	OVb	OVb	OVb

OVb = Original Vacuum Breaker - Unimproved original vacuum breaker aeration

HVR = Hub Venting Runner - Central aeration through runner hub (new hub venting runner)

HSV = Hollow Stay Vane - Aeration through existing hollow stay vanes

For additional details, refer to the FWQIP shown in Table 4 of the 401 Water Quality Application.

#### **Proposed Operational Changes**

- One unit at the Fishing Creek Development is run at efficiency load at least once each day, generating approximately 46 MWh to meet the MADF license requirement of 440 cfs.

**TABLE 14**  
**TARGET RESERVOIR ELEVATIONS FOR FISHING CREEK DEVELOPMENT**

Elevation (ft) at start of day	USGS	Datum	Full Pond = 100	
	Existing	Proposed	Existing	Proposed
January 1	414.2	415.2	97	98
February 1	414.2	415.2	97	98
March 1	414.2	415.2	97	98
April 1	414.2	415.2	97	98
May 1	414.2	415.2	97	98
June 1	414.2	415.2	97	98
July 1	414.2	415.2	97	98
August 1	414.2	415.2	97	98
September 1	414.2	415.2	97	98
October 1	414.2	415.2	97	98
November 1	414.2	415.2	97	98
December 1	414.2	415.2	97	98

## 5.2.4 Reasonable Assurance of Future Compliance and Resource Enhancement

### 5.2.4.1 Dissolved Oxygen - Numeric Standards

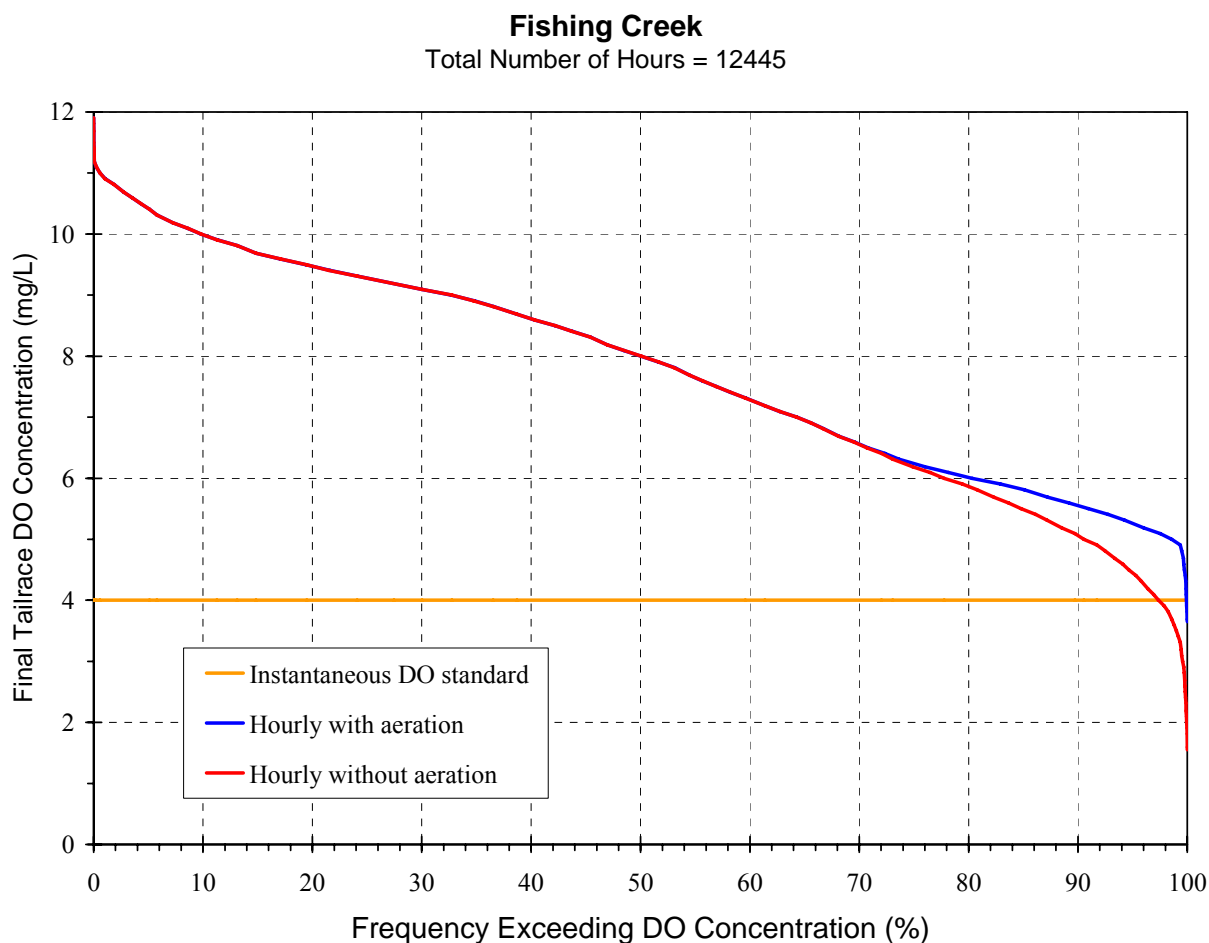
The applicability of turbine venting to the Fishing Creek Development was evaluated by developing a DBM (Appendix C) for each turbine configuration (Fishing Creek = two OVB units and three HSV units).

The DBM was calibrated in 2006 for the one of the HSV turbines and one OVB units.. The field calibration test included the following measurements at various unit power levels: air flow, water flow, initial DO flowing to the turbine, temperature, and DO uptake.

The calibrated DBM for the turbines was used as a tool to predict the DO uptake of the existing turbines by solving the calibrated equation with each average historical hourly flow, temperature, and DO concentration. These historical mean hourly values were calculated from the period of record of water quality measurements made in the Fishing Creek tailrace at 5-minute intervals. All predicted DO uptakes resulting from the calibrated DMB equation were compared to the actual historical monitoring data (Figures 19 through 22).

Hourly DO concentrations were greater than 4.0 mg/l 97.4 percent of the time prior to aeration (Figure 19) and exceeded the daily average of 5.0 mg/l 85.8 percent of the time (Figure 21). These percentages correspond to 329 hours and 222 days of non-compliance without aeration of the turbine water.

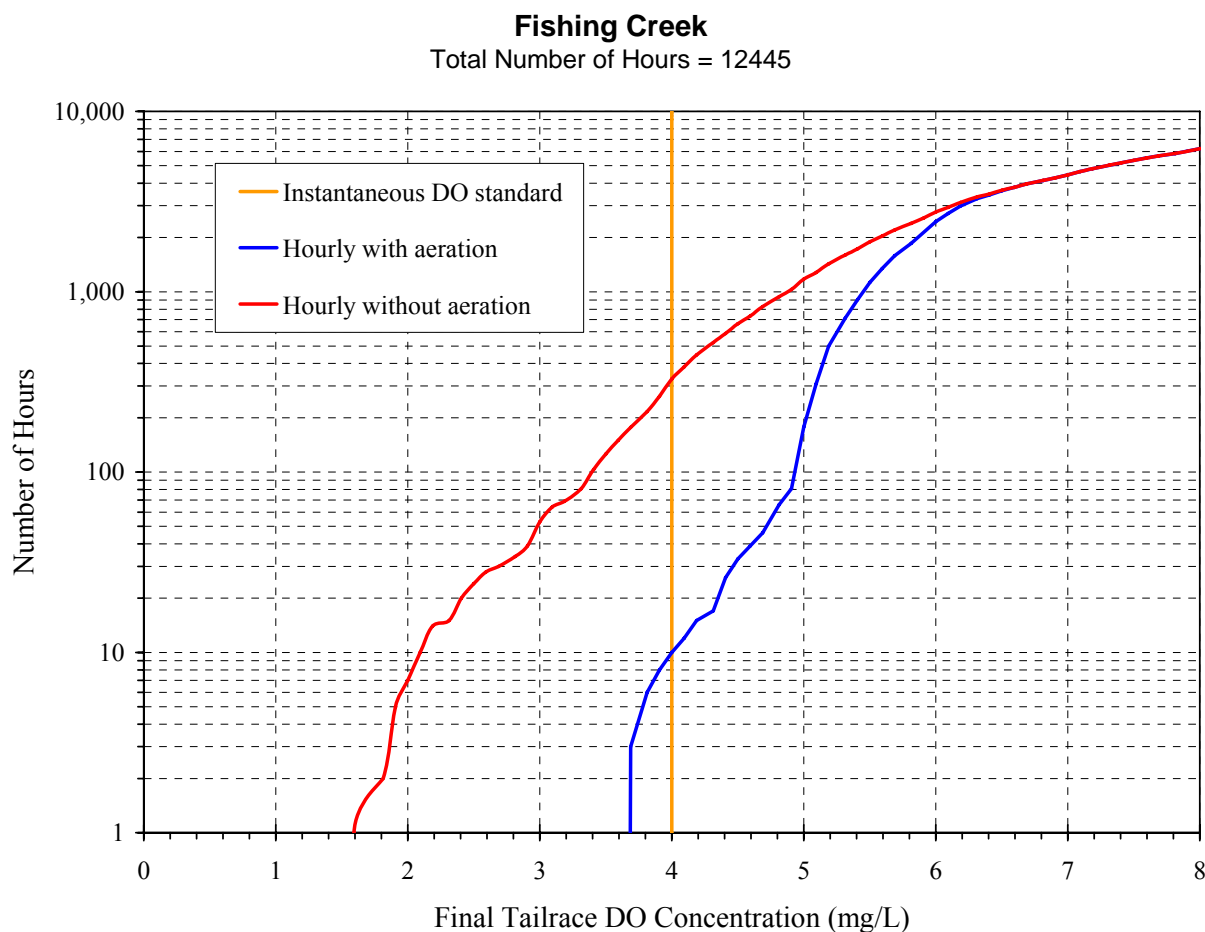
**FIGURE 19**  
**FREQUENCY OF COMPLIANCE WITH INSTANTANEOUS DISSOLVED OXYGEN**  
**STATE WATER QUALITY STANDARDS (4.0 MG/L) FOR HOURLY DISSOLVED**  
**OXYGEN CONCENTRATIONS AT THE FISHING CREEK DEVELOPMENT –**  
**CALCULATED FROM DISCRETE BUBBLE MODEL IN COMPARISON TO THE**  
**HISTORICAL RECORD**



By utilizing turbine venting to increase the DO, predictions based on the using the past historical record as input variables to the calibrated DBM, the future tailrace DOs are significantly

improved. The turbine venting increases the compliance of hourly DO concentrations to 99.94 percent (Figure 19) or, only 10 hours of non-compliance of the 12,445 hours measured (Figure 20). Operator discretion to operate units at more efficient aerating flow rates could further enhance DO uptake. Also, if the average monitor fouling rate is considered and a correction of 0.23 mg/l is added to non-compliant hours, the non-compliant hours drop to 2 hours or less.

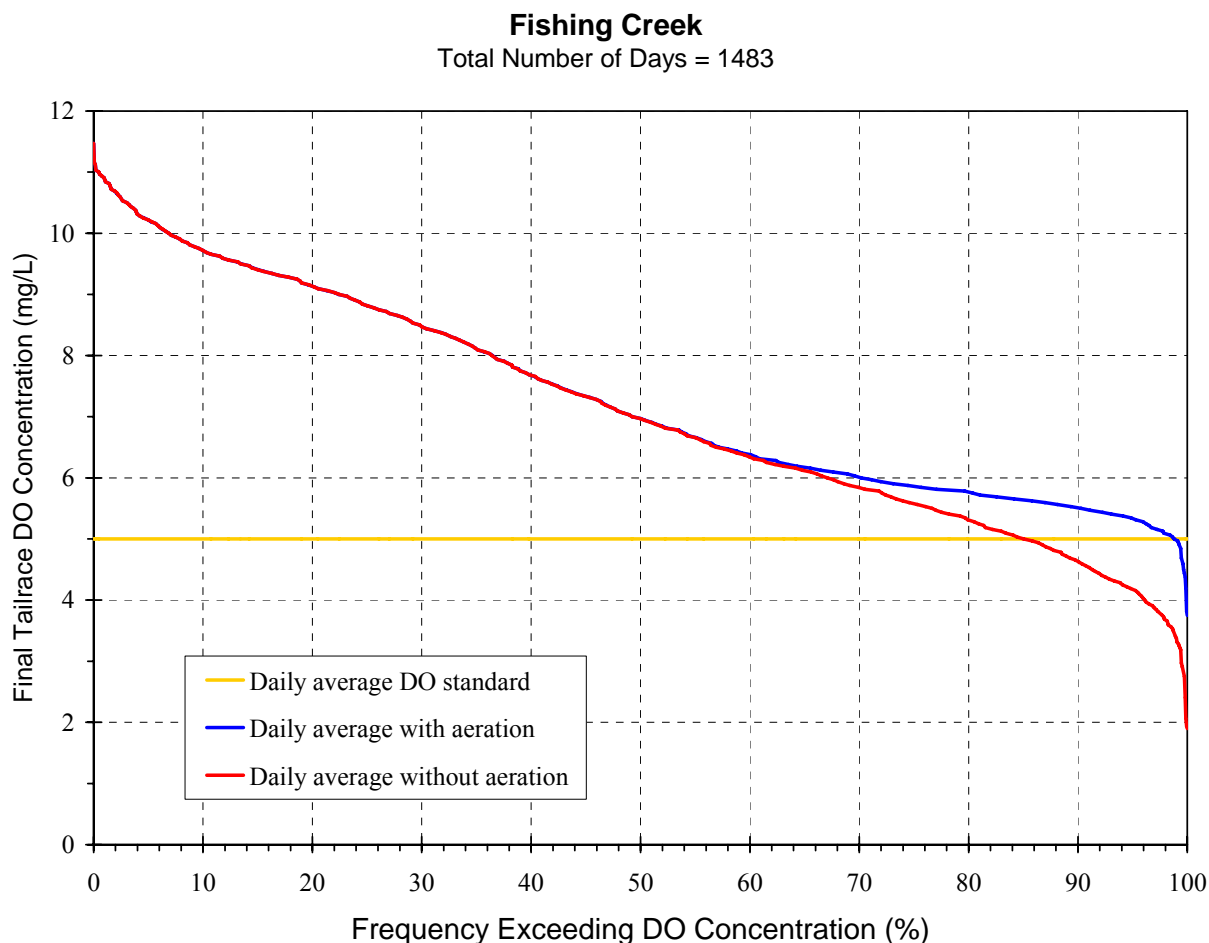
**FIGURE 20**  
**COMPARISON OF HOURS OF NON-COMPLIANCE AT THE FISHING CREEK DEVELOPMENT TO INSTANTANEOUS DISSOLVED OXYGEN STATE WATER QUALITY STANDARDS (4.0 MG/L) CALCULATED FROM DISCRETE BUBBLE MODEL AND THE HISTORICAL RECORD**



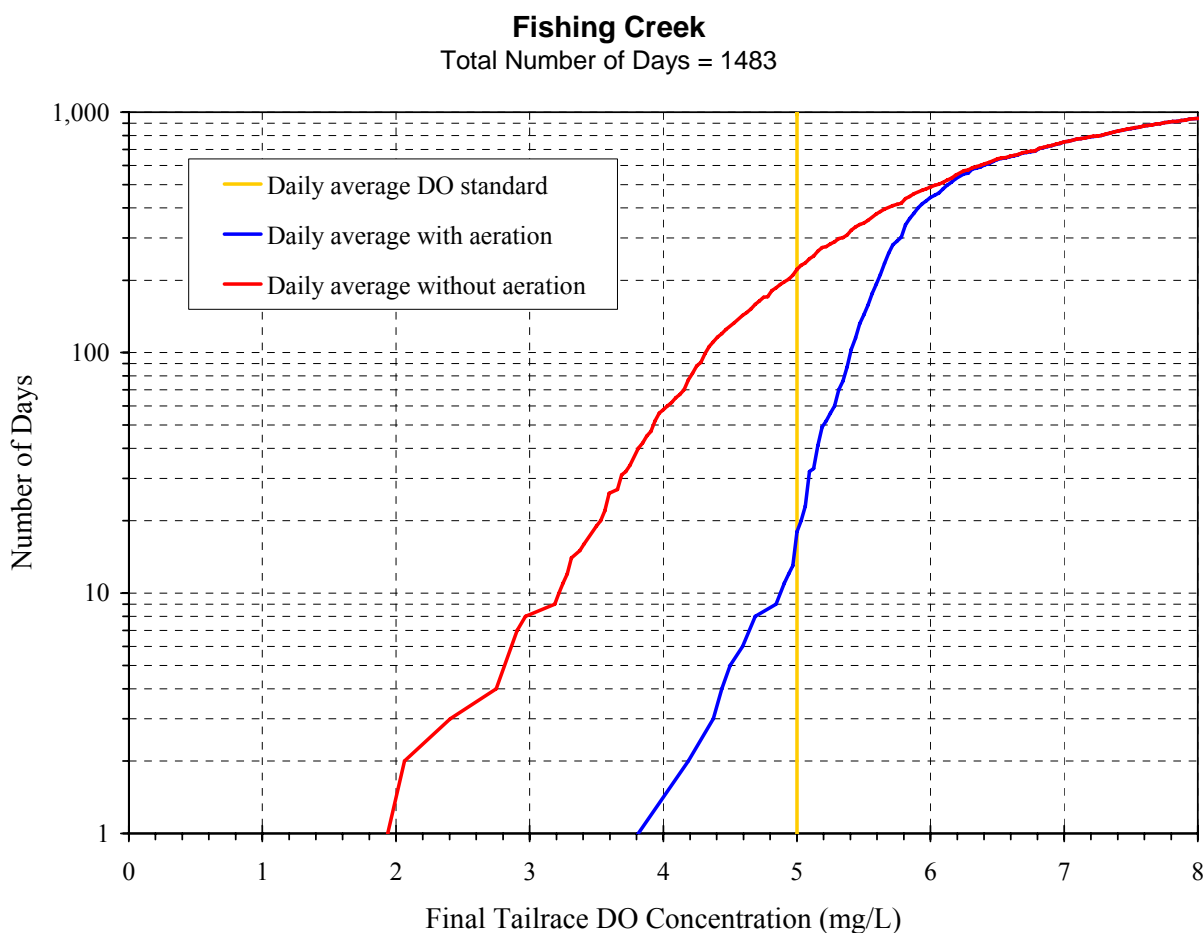
Turbine venting increased compliance with the daily average DO standard of 5.0 mg/l from 85.8 percent to 98.8 percent (Figure 21). This corresponded to not complying with the daily average

standard 13 of 1,483 days. As with hourly non-compliance, operator discretion to operate units at more efficient aerating flow rates should further enhance DO uptake. Correcting for the conservatism of low DO readings due to the average monitor fouling rate almost totally erases all daily average non-compliances.

**FIGURE 21**  
**FREQUENCY OF COMPLIANCE WITH DAILY AVERAGE DISSOLVED OXYGEN**  
**STATE WATER QUALITY STANDARDS (5.0 MG/L) FOR DAILY AVERAGE**  
**DISSOLVED OXYGEN CONCENTRATIONS AT THE FISHING CREEK**  
**DEVELOPMENT – CALCULATED FROM DISCRETE BUBBLE MODEL IN**  
**COMPARISON TO THE HISTORICAL RECORD**



**FIGURE 22**  
**COMPARISON OF DAYS OF NON-COMPLIANCE AT THE FISHING CREEK DEVELOPMENT TO DAILY AVERAGE DISSOLVED OXYGEN STATE WATER QUALITY STANDARDS (5.0 MG/L) CALCULATED FROM DISCRETE BUBBLE MODEL AND THE HISTORICAL RECORD**



#### 5.2.4.2 Resource Enhancement – Existing Use Standards

According to the South Carolina Department of Health and Environmental Control (SCDHEC) Regulation 61-68: Water Classifications and Standards for South Carolina Waters (2004): it is the goal of SCDHEC “to maintain and improve all surface waters to a level that provides for the survival and propagation of a balanced indigenous aquatic community of fauna and flora. These narrative criteria are determined by the Department based on the condition of the waters of the State by measurements of physical, chemical, and biological characteristics of the waters

*according to their classified uses.”* This existing use water quality standard addresses the need for any receiving waters to be of suitable quality to provide for appropriate aquatic communities.

At “lake-to-lake” tailraces (Rhodhiss, Lookout Shoals, Cowans Ford, Mountain Island, Fishing Creek, Great Falls-Dearborn, and Rocky Creek-Cedar Creek), the downstream reservoir backs up into the powerhouse tailrace. At these lake-to-lake locations, the tailwater character will remain lacustrine in nature and would not reasonably be expected to change in nature under minimum continuous flows that are more appropriately intended to enhance riverine aquatic habitat. However, the reservoir headwater in the vicinity of the hydro tailrace may benefit from DO enhancements.

Based on known aquatic resources and the anticipated improvements in DO levels in the Fishing Creek tailrace which are anticipated as a result of a New License consistent with the CRA, the Fishing Creek Development will comply with the SCDHEC narrative water quality standard.

#### 5.2.4.3 Use of Water Quality Modeling to Evaluate Proposed Project Modifications

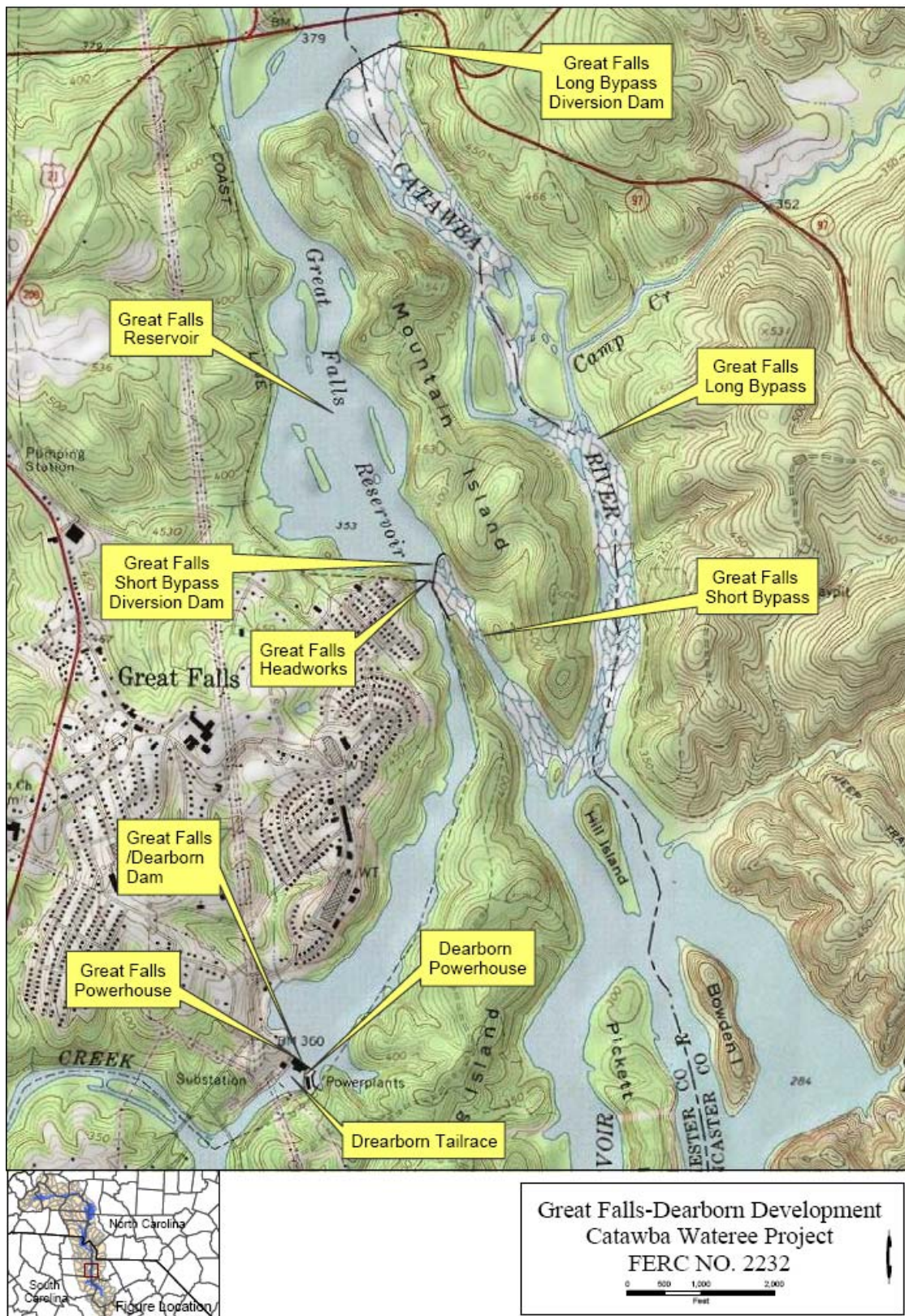
Please refer to Section 7.2 (Assessments of Operational Scenarios).

### 5.3 Great Falls-Dearborn Development

The Great Falls-Dearborn Development consists of the following existing facilities: (1) the Great Falls Diversion Dam consisting of a 1,557.6-foot-long concrete section; (2) the Dearborn Dam consisting of: (a) a 160-foot-long, 103-foot-high, concrete embankment; (b) a 150-foot-long, 103-foot-high intake and bulkhead section; and (c) a 75-foot-long, 103-foot-high bulkhead section; (3) the Great Falls Dam consisting of: (a) a 675-foot-long, 103-foot-high concrete embankment situated in front of the Great Falls Powerhouse (and joined to the Dearborn Dam embankment); and (b) a 250-foot-long intake section (within the embankment); (4) the Great Falls bypassed spillway and headworks section consisting of: (a) a 446.7-foot-long short concrete bypassed reach uncontrolled spillway with a gated trashway (main spillway); (b) a 583.5-foot-long concrete headworks uncontrolled spillway with 4-foot-high flashboards (canal spillway); and (c) a 262-foot-long concrete headworks section situated perpendicular to the main

spillway and the canal spillway, containing 10 openings, each 16 feet wide; (5) a 353-acre reservoir with a normal water surface elevation of 355.8 feet above msl; (6) two powerhouses separated by a retaining wall, consisting of: (a) Great Falls powerhouse: containing eight horizontal Francis-type turbines directly connected to eight generators rated at 3,000 kW for an installed capacity of 24.0 MW, and (b) Dearborn powerhouse: containing three vertical Francis-type turbines directly connected to three generators rated at 15,000 kW for an installed capacity of 42.0 MW, for a total installed capacity of 66.0 MW; and (7) other appurtenances (Figure 23).

**FIGURE 23**  
**GREAT FALLS-DEARBORN DEVELOPMENT**



### 5.3.1 Current Status

#### 5.3.1.1 South Carolina DHEC Assessments and Water Quality Standards

SCDHEC (2005) combined the Great Falls reservoir (pool immediately downstream of Fishing Creek reservoir), which is dammed by Great Falls-Dearborn Development, and the pond formed by Rocky Creek-Cedar Creek Development into the “Cedar Creek Reservoir” assessment. This reservoir, according to SCDHEC (2005), is impaired for aquatic life, but almost fully supports recreation. Excursions from state standards of low DO, high Chlorophyll a, total phosphorus, and total nitrogen occur within the reservoir.

Impaired waters outside the project boundaries that potentially influence water quality within the project include:

- South Carolina 303(d) listings for inflows to Cedar Creek Reservoir were:
  - Fishing Creek watershed: 12 locations, recreation and aquatic life impairment, (fecal coliforms, copper, biological assessment, Chlorophyll a, pH, turbidity)
  - Rocky Creek watershed: 4 locations, aquatic life (copper, bioassessment, total phosphorus, DO, and turbidity)
  - Camp Creek watershed: 1 location, recreation (fecal coliforms)

#### 5.3.1.2 FERC Relicensing Data Summary

##### **Reservoir – Great Falls Reservoir**

##### **Water Quality Findings**

- SCDHEC has no long-term monitoring sites and has not assessed water quality in Great Falls Reservoir.

- Duke Energy operates the Dearborn Development for peaking energy. The units are operated only when the Fishing Creek Development operates since the Great Falls Reservoir has very limited storage.
- Great Falls Hydro is operated only when water availability exceeds Dearborn's capacity.
- Short retention times (averaging 1 day) result in the water quality essentially mimicking the water quality released from Fishing Creek Reservoir.
- Fishing Creek (River) proportionately dilutes the concentrations of the chemical constituents released from Fishing Creek reservoir.

### Biological Resource Findings

The following information on the biological resources of Great Falls Reservoir was provided in Book 2 of 10, Application for New License Supplement and Clarification - Aquatics 01 Study Report (Duke Energy 2007):

- A total of 25 species of fish, plus hybrid sunfish, were observed during spring shoreline electrofishing (1994–1997; 2000) in the littoral zone of the Great Falls-Dearborn Reservoir.
- Average total biomass of these studies yielded was 83.3 kilograms per kilometer of shoreline, with mean compositions consisting of 48 percent common carp, 18 percent largemouth bass, 13 percent sunfish (primarily redear and bluegill), and 10 percent catfish (primarily white and channel).
- Average fish density was 267.1 fish per kilometer of shoreline.
- Fish community composition, numerically, predominantly sunfish with bluegill (21 percent), redear (14 percent), pumpkinseed (9 percent) and redbreast (9 percent) the most numerous species. Largemouth bass and gizzard shad were also relatively abundant, averaging 14 percent and 11 percent of total density, respectively.

**Tailrace – Great Falls-Dearborn****Water Quality Findings**

- Ten years of tailrace continuous monitoring at  $\approx$  5-minute intervals for temperature, pH, and DO revealed that only DO did not meet state water quality standards for turbine releases.
- On the average, during May through November, 29 percent of the hourly average DO concentrations released from the Dearborn Development are lower than the current state standard of 4.0 mg/l instantaneous.
- On the average, during May through November, 57 percent of the daily average DO concentrations released from the Dearborn Development are lower than the current state standard of 5.0 mg/l daily average.
- Actual 4-year (1997–2000) average nutrient Dearborn releases compared to Fishing Creek Releases:
  - Phosphorus – Fishing Creek = 221 mg/l; Dearborn = 204 mg/l
  - Dissolved Organics – Fishing Creek = 5.9 mg/l; Dearborn = 6.0 mg/l
  - Particulate Organics – Fishing Creek = 3.3 mg/l; Dearborn = 2.3 mg/l

**Great Falls-Dearborn Long Bypassed Reach****Biological Resource Findings**

The following information on the biological resources of the Great Falls-Dearborn Bypassed Reaches was provided in Book 2 of 10, Application for New License Supplement and Clarification - Aquatics 01 Study Report (Duke Energy 2007):

- The Great Falls Long Bypassed Reach consists of a stream segment (downstream of the Camp Creek confluence) and relatively isolated pools. This area was qualitatively sampled once in summer by backpack electrofishing techniques to determine fish species composition (RM 101.8 in the Great Falls Long Bypassed Reach).

- Isolated pools were sampled with rotenone in spring and summer to determine fish species composition. Isolated pools in the bedrock and boulder habitat were selected for manageable size and controllable outlets (to allow for thorough detoxification of the rotenone) and were determined in cooperation with SCDNR staff. Three pools with varying degrees of overhead cover were sampled in the upper reach during spring and one pool in each of the lower and middle reaches (both with minimal overhead cover) were sampled during summer. Sampling locations ranged from RM 101.8 through 103.6 in the Great Falls Long Bypassed Reach.
- The species composition of the fish community at the middle section sampled with rotenone was typical for the habitat type present in this reach with 24 fish species of 8 families being collected, including sunfish, minnows, suckers, catfish and others.

### 5.3.2 Water Quality Issue Identification and Evaluation

#### **Great Falls-Dearborn Tailrace**

- Enhance DO concentrations of water released from powerhouse to meet state standards.

#### **Great Falls-Dearborn Bypassed Reaches**

- Establish continuous flow regimes for enhanced fish habitat in these two historically dewatered stream reaches.

### 5.3.3 Project Modifications for Water Quality Compliance and Resource Enhancement

Stakeholder negotiations and engineering evaluations have resulted in proposed structural changes and operational changes.

**Proposed Engineering Changes**

**TABLE 15**  
**GREAT FALLS DEVELOPMENT AERATION CAPABILITIES**

<b>Turbine/ Other Release Point</b>	<b>Original</b>	<b>Current (as of 12/31/2006)</b>	<b>Future (from FWQIP)</b>
Great Falls Unit 1	NHS	NHS	NHS
Great Falls Unit 2	NHS	NHS	NHS
Great Falls Unit 3	NHS	NHS	NHS
Great Falls Unit 4	NHS	NHS	NHS
Great Falls Unit 5	NHS	NHS	NHS
Great Falls Unit 6	NHS	NHS	NHS
Great Falls Unit 7	NHS	NHS	NHS
Great Falls Unit 8	NHS	NHS	NHS
Great Falls Diversion Overflow	NA	NA	BCA CMR
Great Falls Headworks Trash Gate	NA	NA	BCA CMR

NHS = None - Horizontal Shaft - Conventional aeration is not possible on a horizontal shaft turbine

BCA = Bypass Channel Aeration - Natural aeration in bypass channel

CMR = Dedicated continuous minimum flow turbine, valve or modification

For additional details, refer to the FWQIP shown in Table 4 of the 401 Water Quality Application.

**TABLE 16**  
**DEARBORN DEVELOPMENT AERATION CAPABILITIES**

<b>Turbine/ Other Release Point</b>	<b>Original</b>	<b>Current (as of 12/31/2006)</b>	<b>Future (from FWQIP)</b>
Dearborn Unit 1	OVB	HSV	HSV
Dearborn Unit 2	OVB	HSV	HSV
Dearborn Unit 3	OVB	HSV	HSV

OVB = Original Vacuum Breaker - Unimproved original vacuum breaker aeration

HSV = Hollow Stay Vane - Aeration through existing hollow stay vanes

For additional details, refer to the FWQIP shown in Table 4 of the 401 Water Quality Application.

**Proposed Operational Changes**

**TABLE 17**  
**TARGET RESERVOIR ELEVATIONS FOR THE GREAT FALLS-DEARBORN**  
**DEVELOPMENT**

Elevation (ft) at start of day	USGS	Datum	Full Pond = 100	
	Existing	Proposed	Existing	Proposed
January 1	353.3	353.3	97.5	97.5
February 1	353.3	353.3	97.5	97.5
March 1	353.3	353.3	97.5	97.5
April 1	353.3	353.3	97.5	97.5
May 1	353.3	353.3	97.5	97.5
June 1	353.3	353.3	97.5	97.5
July 1	353.3	353.3	97.5	97.5
August 1	353.3	353.3	97.5	97.5
September 1	353.3	353.3	97.5	97.5
October 1	353.3	353.3	97.5	97.5
November 1	353.3	353.3	97.5	97.5
December 1	353.3	353.3	97.5	97.5

- Minimum Habitat Continuous Flows - The habitat flows in Table 18 for the Great Falls-Dearborn Development in the CRA are based on study results, stakeholder negotiations, and CHEOPS analysis of flow levels that provided improved aquatic habitat, balanced other water user interests, and which were at levels which could be sustained over the life of the New License.

**TABLE 18**  
**MINIMUM BYPASS FLOW REQUIREMENTS FOR THE GREAT FALLS-DEARBORN**  
**DEVELOPMENT**

Flow (cfs) for month	MADF Release		Continuous Release Long Bypass		Continuous Release Short Bypass	
	Existing	Proposed	Existing	Proposed	Existing	Proposed
January	444	0	0	450	0	100
Feb 14	444	0	0	450	0	100
Feb 15	444	0	0	850	0	100
March	444	0	0	850	0	100
April	444	0	0	850	0	100
May 15	444	0	0	850	0	100
May 16	444	0	0	450	0	100
June	444	0	0	450	0	100
July	444	0	0	450	0	100
August	444	0	0	450	0	100
September	444	0	0	450	0	100
October	444	0	0	450	0	100
November	444	0	0	450	0	100
December	444	0	0	450	0	100

- One unit at the Dearborn Development is run at efficiency load at least once each day, generating approximately 53 MWh to meet the MADF license requirement of 444 cfs.
- There are no measured leakage flows to use for the existing flow at the Great Falls Long and Short Bypassed Reach.

### 5.3.4 Reasonable Assurance of Future Compliance and Resource Enhancement

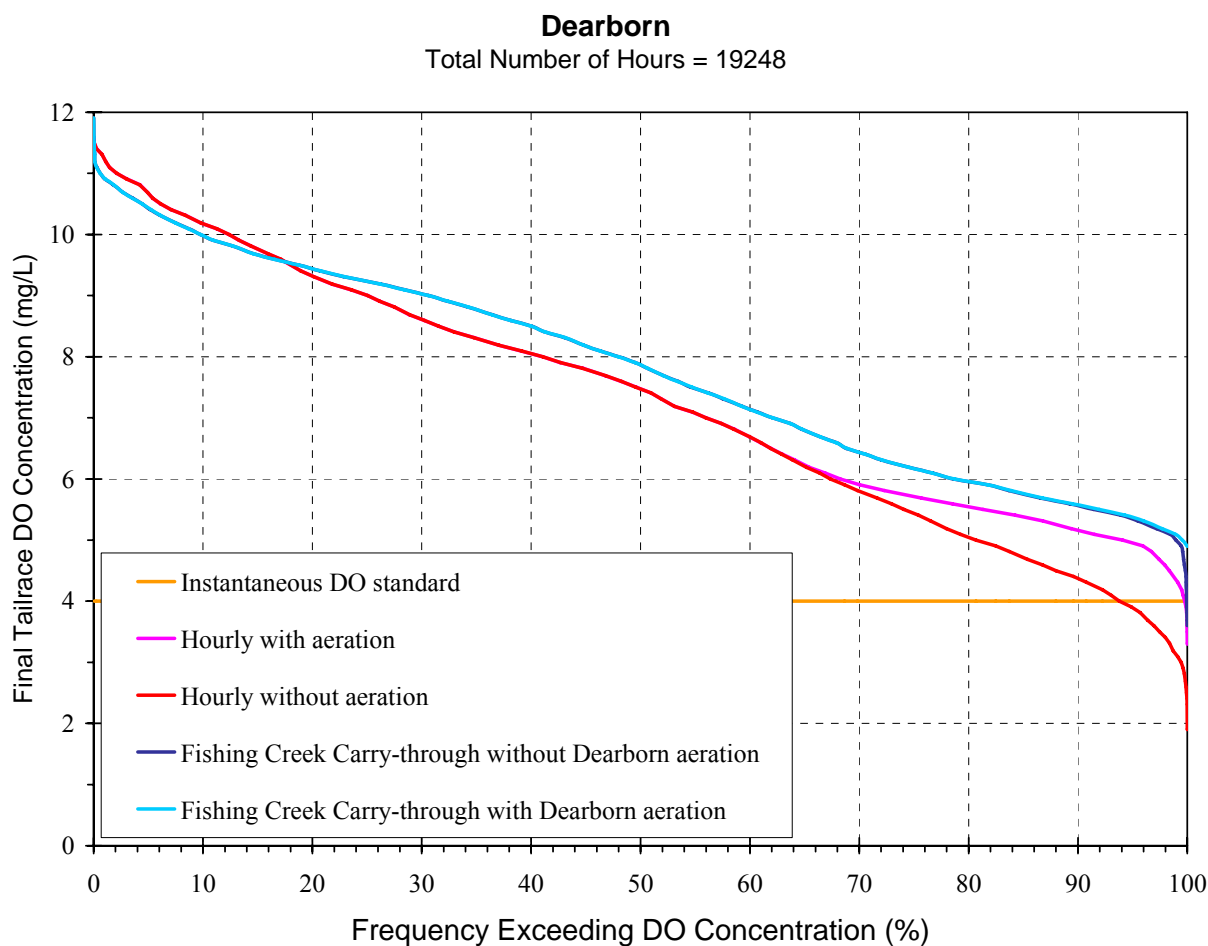
#### 5.3.4.1 Dissolved Oxygen - Numeric Standards

The applicability of turbine venting to the Great Falls-Dearborn Development was evaluated by developing a DBM (Appendix C) for each turbine configuration (Dearborn = 3 HSV units).

The DBM was calibrated in 2006 for the one of the Dearborn HSV turbines. The field calibration test included the following measurements at various unit power levels: air flow, water flow, initial DO flowing to the turbine, temperature, and DO uptake. The calibrated DBM for

the turbines was used as a tool to predict the DO uptake of the existing turbines by solving the calibrated equation with each historical hourly flows, temperatures, and DO concentrations. These historical mean hourly values were calculated from the long period of record of water quality measurements made in the tailrace at 5-minute intervals.

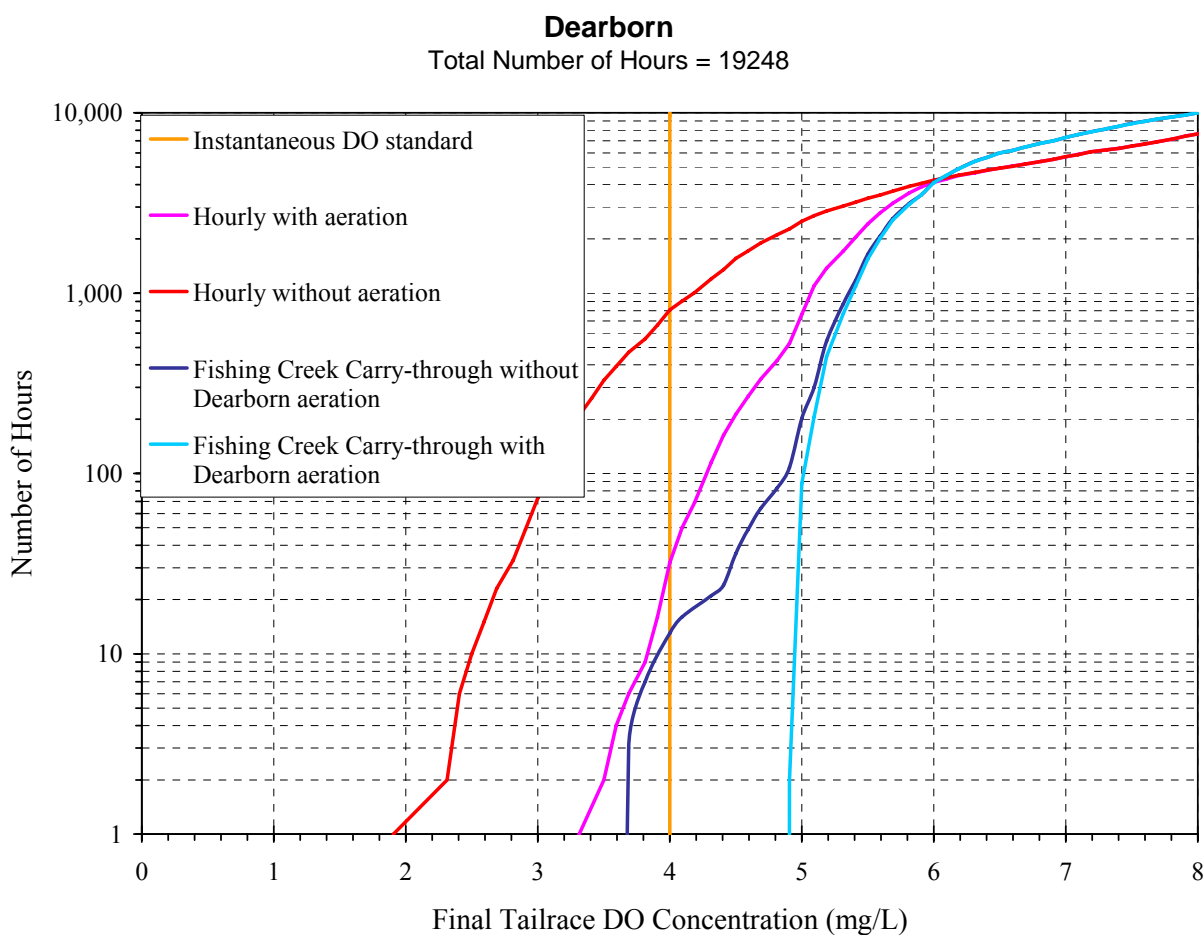
**FIGURE 24**  
**FREQUENCY OF COMPLIANCE WITH INSTANTANEOUS DISSOLVED OXYGEN**  
**STATE WATER QUALITY STANDARDS (4.0 MG/L) FOR HOURLY DISSOLVED**  
**OXYGEN CONCENTRATIONS AT THE DEARBORN DEVELOPMENT –**  
**CALCULATED FROM DISCRETE BUBBLE MODEL IN COMPARISON TO THE**  
**HISTORICAL RECORD**



Historically, the Dearborn Development had a 94.9 percent compliance with the 4.0 mg/l instantaneous standard (Figure 24). However, compliance with the daily average standard of 5.0

mg/l was 70.1 percent (Figure 25) prior to turbine aeration. Turbine venting boosted these percentages to 99.9 percent and 91.97 percent, respectively.

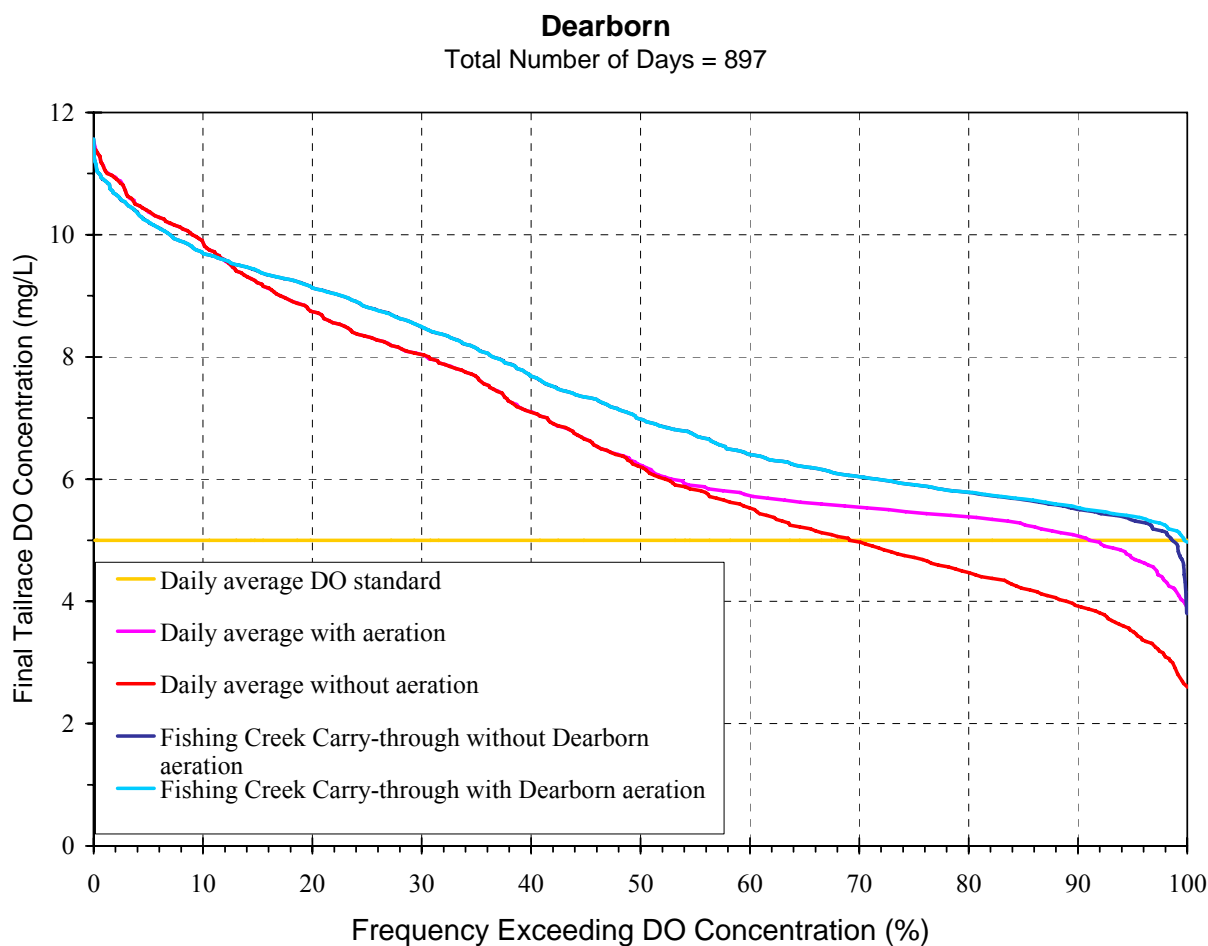
**FIGURE 25**  
**COMPARISON OF HOURS OF NON-COMPLIANCE AT THE DEARBORN**  
**DEVELOPMENT TO INSTANTANEOUS DISSOLVED OXYGEN STATE WATER**  
**QUALITY STANDARDS (4.0 MG/L) CALCULATED FROM DISCRETE BUBBLE**  
**MODEL AND THE HISTORICAL RECORD**



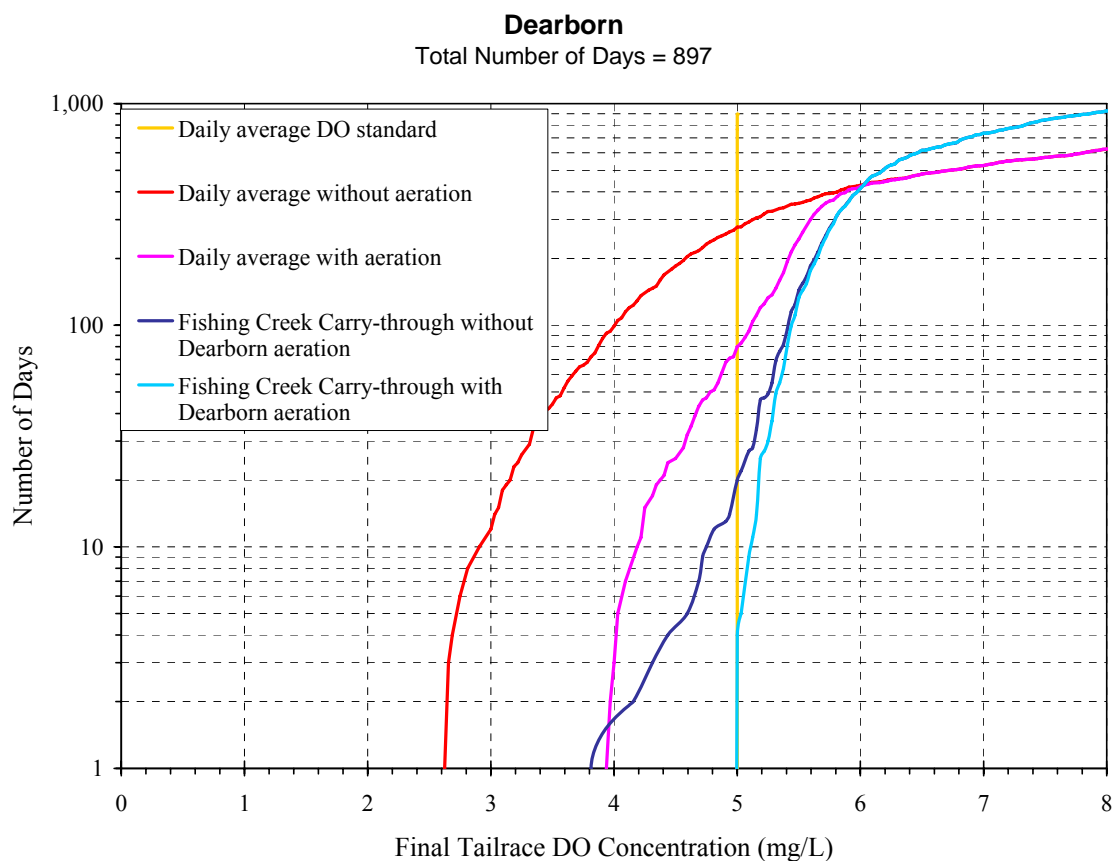
Even though the aeration at Dearborn contributes significantly to DO improvement to the water released from Dearborn, a more significant contribution of DO comes from Fishing Creek upstream of Dearborn. The pond between Fishing Creek and Dearborn has an average retention time of 1 day, less at higher operating loads at the Fishing Creek Development. This short retention time coupled with significant aeration at Fishing Creek would significantly increase the

DO received at Dearborn. To simulate this impact (but still remain very conservative), one mg/l of DO was added to the hourly historical values (in the future, the DO received at Dearborn should be increased by significantly more than an additional 1 mg/l). The DBM was rerun with the modified DOs. Results indicate complete compliance (100 percent) to both standards, i.e. the instantaneous 4.0 mg/l and the daily average 5.0 mg/l.

**FIGURE 26**  
**FREQUENCY OF COMPLIANCE WITH DAILY AVERAGE DISSOLVED OXYGEN**  
**STATE WATER QUALITY STANDARDS (5.0 MG/L) FOR DAILY AVERAGE**  
**DISSOLVED OXYGEN CONCENTRATIONS AT THE DEARBORN DEVELOPMENT**  
**– CALCULATED FROM DISCRETE BUBBLE MODEL IN COMPARISON TO THE**  
**HISTORICAL RECORD**



**FIGURE 27**  
**COMPARISON OF DAYS OF NON-COMPLIANCE AT THE DEARBORN DEVELOPMENT TO DAILY AVERAGE DISSOLVED OXYGEN STATE WATER QUALITY STANDARDS (5.0 MG/L) CALCULATED FROM DISCRETE BUBBLE MODEL AND THE HISTORICAL RECORD**



#### 5.3.4.2 Resource Enhancement – Existing Use Standards

According to the South Carolina Department of Health and Environmental Control (SCDHEC) Regulation 61-68: Water Classifications and Standards for South Carolina Waters (2004): it is the goal of SCDHEC “to maintain and improve all surface waters to a level that provides for the survival and propagation of a balanced indigenous aquatic community of fauna and flora. These narrative criteria are determined by the Department based on the condition of the waters of the State by measurements of physical, chemical, and biological characteristics of the waters according to their classified uses.” This existing use water quality standard addresses the need for any receiving waters to be of suitable quality to provide for appropriate aquatic communities.

The allocation of the water resources of the Great Falls-Dearborn Development was based on water quality, flow/habitat analyses, and negotiation of releases appropriate for addressing the above resource enhancement goals. Habitat analyses of the Great Falls short bypassed reach (Flow vs. Weighted Usable Area) and Great Falls long bypassed reach (2-dimensional IFIM analyses) indicated that flow that releases provided as a result of the CRA would provide significant enhancements for the aquatic resources in these reaches. After rigorous analysis and evaluation the Instream Flow Study Team decided that the most appropriate overall habitat goal in the Great Falls Long Bypassed Reach was that the bypass flow should attain a 90 percent wetted area in the reach. The CRA flows provided the following gains in wetted or weighted usable area:

**Long Bypassed Channel:**

- 800 cfs provides 86 percent of the total wetted area.
- 450 cfs provides 77 percent of the total wetted area.
- Monthly weighted annual average wetted area is 79 percent.

Since an annual average of only 79 percent wetted area was achieved in the Great Falls Long Bypassed Reach by the CRA flows and the level desired by resource agencies of 90 percent of wetted area was not quite achieved in the Great Falls Long Bypass Reach, suitable and appropriate mitigation was provided as described in Section 6 (Flow Mitigation Package). Based on CHEOPS analysis, the flows provided in the two Great Falls Bypassed Reaches is sustainable for the term of a New License.

Based on known aquatic resources and the anticipated improvements in DO levels in the Great Falls-Dearborn tailrace an enhancements to flow and in the Long Bypassed Reach, which are anticipated as a result of a New License consistent with applicable sections of the CRA, the Great Falls-Dearborn Development will comply with the SCDHEC narrative water quality standard.

At “lake-to-lake” tailraces (Rhodhiss, Lookout Shoals, Cowans Ford, Mountain Island, Fishing Creek, Great Falls-Dearborn, and Rocky Creek-Cedar Creek), the downstream reservoir backs up

into the powerhouse tailrace. At these lake-to-lake locations, the tailwater character will remain lacustrine in nature and would not reasonably be expected to change in nature under minimum continuous flows that are more appropriately intended to enhance riverine aquatic habitat. However, the reservoir headwater in the vicinity of the hydro tailrace may benefit from DO enhancements.

## **5.4 Rocky Creek-Cedar Creek Development**

The Rocky Creek-Cedar Creek Development consists of the following existing facilities: (1) a U-shaped concrete gravity overflow spillway with (a) a 130-foot-long section (on the east side) that forms a forebay canal to the Cedar Creek powerhouse and contains two Stoney gates, each 45 feet wide by 25 feet high; (b) a 1,025-foot-long, 69-foot-high concrete gravity overflow spillway; and (c) a 213-foot-long section (on the west side) that forms the upper end of the forebay canal for the Rocky Creek powerhouse; (2) a 450-foot-long concrete gravity bulkhead section that completes the lower end of the Rocky Creek forebay canal; (3) a 748-acre reservoir with a normal water surface elevation of 284.4 feet above msl; (4) two powerhouses consisting of: (a) Cedar Creek powerhouse (on the east): containing three vertical Francis-type turbines directly connected to three generators, one rated at 15,000 kW, and two rated at 18,000 kW for an installed capacity of 43.0 MW; and (b) Rocky Creek powerhouse (on the west): containing eight horizontal twin-runner Francis-type turbines directly connected to eight generators, six rated at 3,000 kW and two rated at 4,500 kW for an installed capacity of 25.8 MW, for a total installed capacity of 68.8 MW; and (5) other appurtenances (Figure 28).

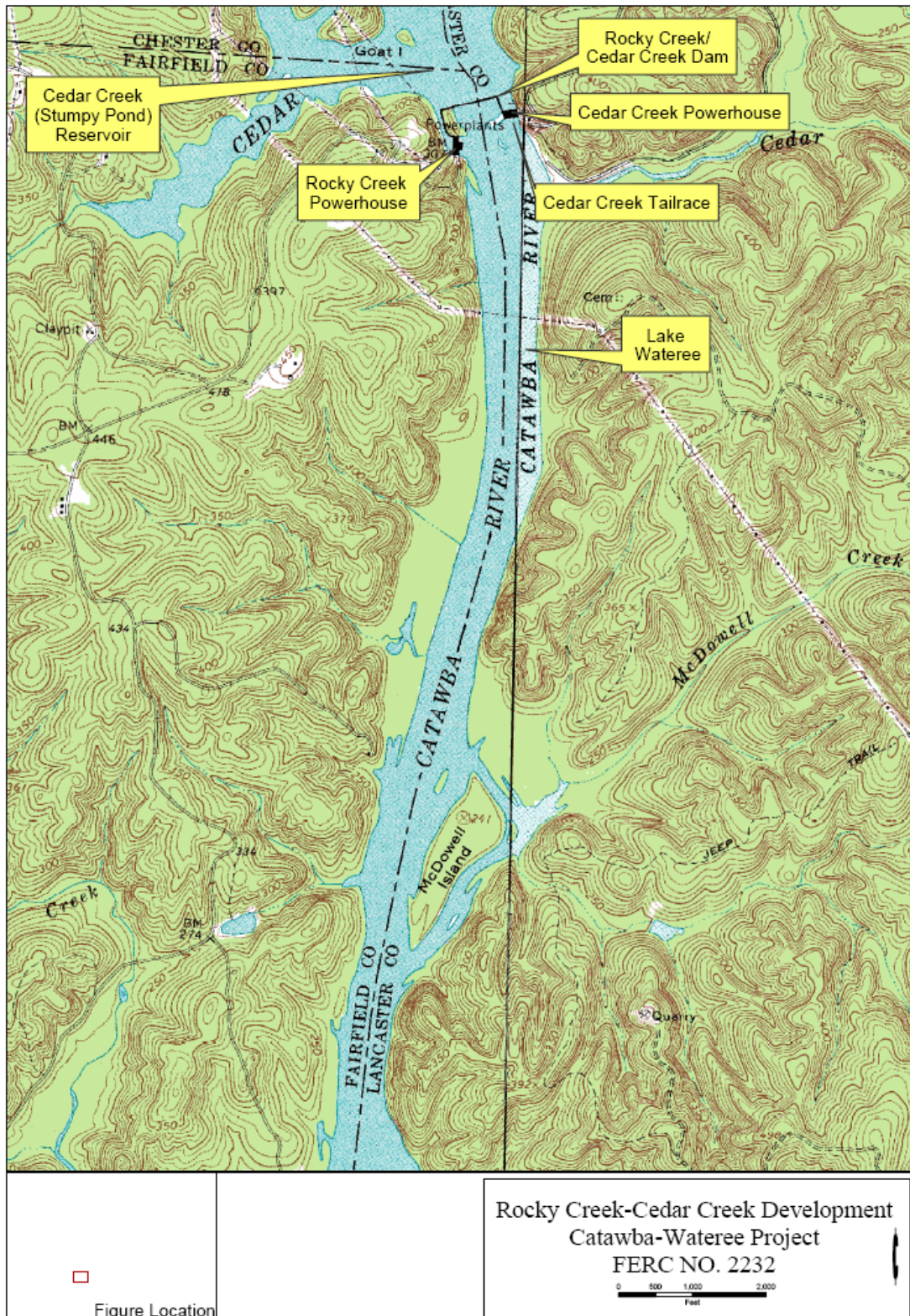
### **5.4.1 Current Status**

#### **5.4.1.1 South Carolina DHEC Assessments and Water Quality Standards**

SCDHEC (2005) combined the Great Falls Reservoir (pool immediately downstream of Fishing Creek Reservoir), which is dammed by Great Falls-Dearborn Development, and the pond formed by Rocky Creek-Cedar Creek Development into the “Cedar Creek Reservoir” assessment. This reservoir, according to SCDHEC (2005), is impaired for aquatic life, but almost fully supports

recreation. Excursions from state standards of low DO, high Chlorophyll a, total phosphorus, and total nitrogen occur within the reservoir.

**FIGURE 28**  
**ROCKY CREEK-CEDAR CREEK DEVELOPMENT**



Impaired waters inside the project boundaries include:

- Cedar Creek Reservoir: 6 locations, aquatic life impairment (total phosphorus, total nitrogen, DO, and Chlorophyll a)

Impaired waters outside the project boundaries that potentially influence water quality within the project include:

- South Carolina 303(d) listings for inflows to Cedar Creek Reservoir were:
  - Fishing Creek watershed: 12 locations, recreation and aquatic life impairment, (fecal coliforms, copper, biological assessment, Chlorophyll a, pH, turbidity)
  - Rocky Creek watershed: 4 locations, aquatic life (copper, bioassessment, total phosphorus, DO, and turbidity)
  - Camp Creek watershed: 1 location, recreation (fecal coliforms)

#### 5.4.1.2 FERC Relicensing Data Summary

### **Reservoir – Cedar Creek Lake (Stumpy Pond)**

#### Water Quality Findings

- Duke Energy operates the Cedar Creek Development for peaking energy. The units are operated only when Fishing Creek and Dearborn Developments operate since the Great Falls Reservoir and Cedar Creek Reservoir have very limited storage.
- Rocky Creek Hydro is operated only when water availability exceeds Cedar Creeks' capacity.
- Very short retention times (2 days on average) in the channel between the Dearborn Development and Cedar Creek Development result in the water quality essentially mimicking the water quality released from Dearborn.
- The reservoir section from the Catawba bypassed channel to the Cedar Creek Development has a longer retention time as indicated by vertically stratified DO concentrations, pH, and

conductivity and with lower nutrient concentrations than found downstream of the Dearborn Development. These conditions are consistent with the development of high algal concentrations in the surface layers and high sediment oxygen demands in the upper portions of Cedar Creek Reservoir.

- Rocky Creek (River) proportionately dilutes the concentrations of the chemical constituents released from Fishing Creek Reservoir.
- Any proposed changes in storage and release patterns from the Fishing Creek Development, including supplemental flow through the Great Falls Long Bypassed Reach, would be reflected in Cedar Creek Reservoir, including, but not limited to an increase in the DO levels flowing into Cedar Creek Reservoir from the bypassed reach.

### Biological Resource Findings

The following information on the biological resources of Cedar Creek Lake was provided in Book 2 of 10, Application for New License Supplement and Clarification - Aquatics 01 Study Report (Duke Energy 2007):

- Twenty-eight species of fish, plus hybrid sunfish, were collected in spring shoreline electrofishing (1994–1997; 2000).
- Biomass of fish collected averaged 95.5 kg per kilometer of shoreline, consisting mostly of largemouth bass (48 percent) and common carp (34 percent).
- Total numbers of fish collected averaged 407.1 fish per kilometer of shoreline. Sunfish dominated the catch numerically. Bluegill comprised 36 percent of total fish density on average, redbreast 8 percent, pumpkinseed 7 percent, and redear 4 percent; largemouth bass were also numerically abundant, constituting 18 percent of total fish.
- No fish kills have been documented on Cedar Creek Reservoir.

**Tailrace – Rocky Creek-Cedar Creek****Water Quality Findings**

- Ten years of tailrace continuous monitoring at  $\approx$  5-minute intervals for temperature, pH, and DO revealed that only DO did not meet state water quality standards for turbine releases.
- On the average, during May through November, 18 percent of the hourly average DO concentrations released from the Cedar Creek Development are lower than the current state standard of 4.0 mg/l instantaneous
- On the average, during May through November, 45 percent of the daily average DO concentrations released from the Cedar Creek Development are lower than the current state standard of 5.0 mg/l daily average
- Actual 4-year (1997–2000) average nutrient Cedar Creek/Rocky Creek Releases Compared to Fishing Creek Releases:
  - Phosphorus – Dearborn = 221 mg/l; Cedar Creek = 221 mg/l
  - Dissolved Organics – Dearborn = 6.0 mg/l; Cedar Creek = 5.9 mg/l
  - Particulate Organics – Dearborn = 2.3 mg/l; Cedar Creek = 9.3 mg/l

**5.4.2 Water Quality Issue Identification and Evaluation****Rocky Creek-Cedar Creek Tailrace**

- Enhance DO concentrations of water released from powerhouse to meet state standards.

**5.4.3 Project Modifications for Water Quality Compliance and Resource Enhancement**

Stakeholder negotiations and engineering evaluations have resulted in proposed structural changes and operational changes.

**Proposed Engineering Changes**

**TABLE 19**  
**ROCKY CREEK DEVELOPMENT AERATION CAPABILITIES**

<b>Turbine/ Other Release Point</b>	<b>Original</b>	<b>Current (as of 12/31/2006)</b>	<b>Future (from FWQIP)</b>
Rocky Creek Unit 1	NHS	NHS	NHS
Rocky Creek Unit 2	NHS	NHS	NHS
Rocky Creek Unit 3	NHS	NHS	NHS
Rocky Creek Unit 4	NHS	NHS	NHS
Rocky Creek Unit 5	NHS	NHS	NHS
Rocky Creek Unit 6	NHS	NHS	NHS
Rocky Creek Unit 7	NHS	NHS	NHS
Rocky Creek Unit 8	NHS	NHS	NHS

NHS = None - Horizontal Shaft - Conventional aeration is not possible on a horizontal shaft turbine.

For additional details, refer to the FWQIP shown in Table 4 of the 401 Water Quality Application.

**TABLE 20**  
**CEDAR CREEK DEVELOPMENT AERATION CAPABILITIES**

<b>Turbine/ Other Release Point</b>	<b>Original</b>	<b>Current (as of 12/31/2006)</b>	<b>Future (from FWQIP)</b>
Cedar Creek Unit 1	OVB	EVB	EVB
Cedar Creek Unit 2	OVB	HVR	HVR
Cedar Creek Unit 3	OVB	HVR	HVR

OVB = Original Vacuum Breaker - Unimproved original vacuum breaker aeration

EVB = Enhanced Vacuum Breaker - Improved vacuum breaker aeration (modified piping and/or headcover)

HVR = Hub Venting Runner - Central aeration through runner hub (new hub venting runner)

For additional details, refer to the FWQIP shown in Table 4 of the 401 Water Quality Application.

**Proposed Operational (flow) Changes**

- One unit at the Cedar Creek Development is run at efficiency load at least once each day, generating approximately 40 MWh to meet the MADF license requirement of 445 cfs.

**TABLE 21**  
**TARGET RESERVOIR ELEVATIONS FOR THE ROCKY CREEK-CEDAR CREEK**  
**DEVELOPMENT**

Elevation (ft) at start of day	USGS	Datum	Full Pond	= 100
	Existing	Proposed	Existing	Proposed
January 1	281.9	281.9	97.5	97.5
February 1	281.9	281.9	97.5	97.5
March 1	281.9	281.9	97.5	97.5
April 1	281.9	281.9	97.5	97.5
May 1	281.9	281.9	97.5	97.5
June 1	281.9	281.9	97.5	97.5
July 1	281.9	281.9	97.5	97.5
August 1	281.9	281.9	97.5	97.5
September 1	281.9	281.9	97.5	97.5
October 1	281.9	281.9	97.5	97.5
November 1	281.9	281.9	97.5	97.5
December 1	281.9	281.9	97.5	97.5

#### 5.4.4 Reasonable Assurance of Future Compliance and Resource Enhancement

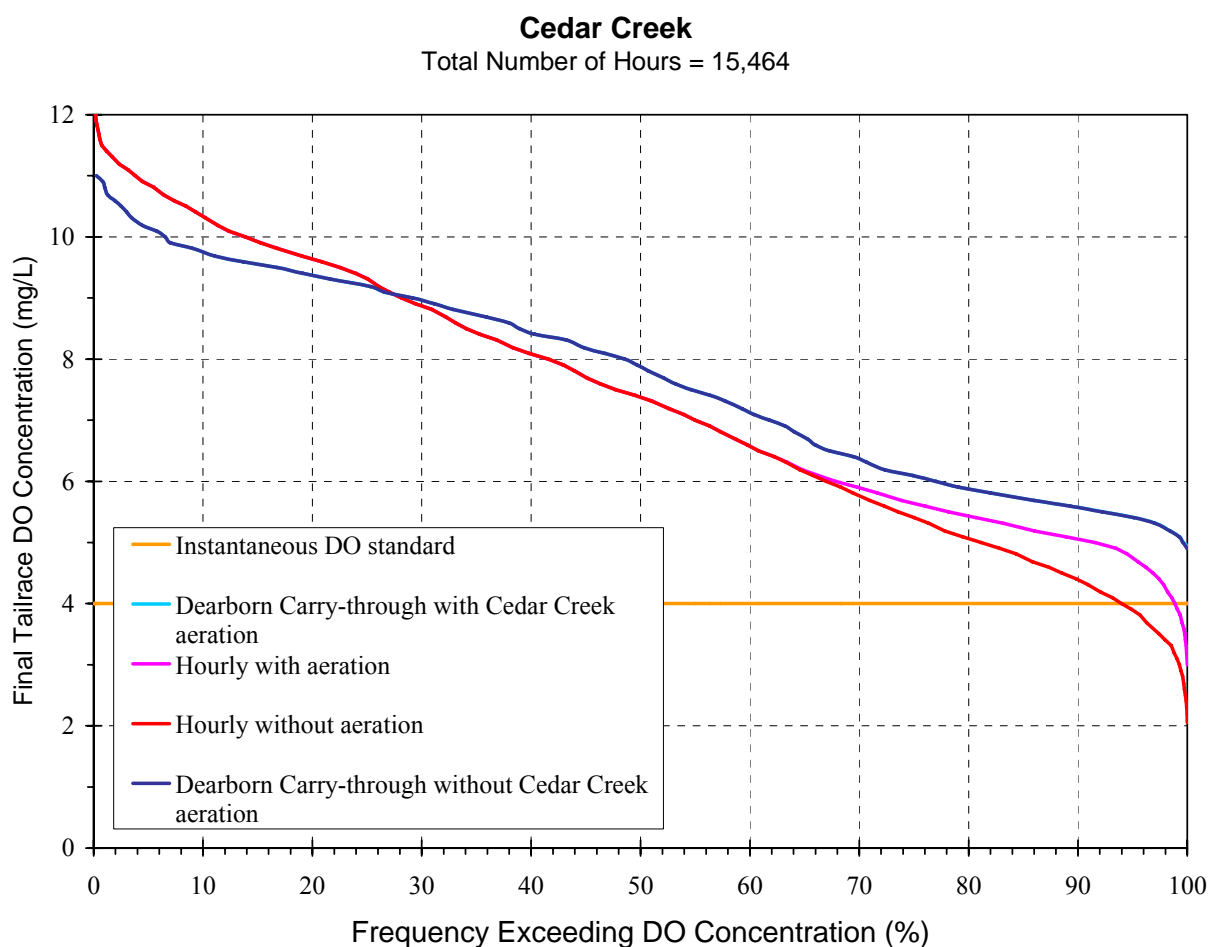
##### 5.4.4.1 Dissolved Oxygen - Numeric Standards

The applicability of turbine venting to the Cedar Creek Development was evaluated by developing a DBM (Appendix C) for each turbine configuration (Cedar Creek = 1 EVB unit and 2 HVR units).

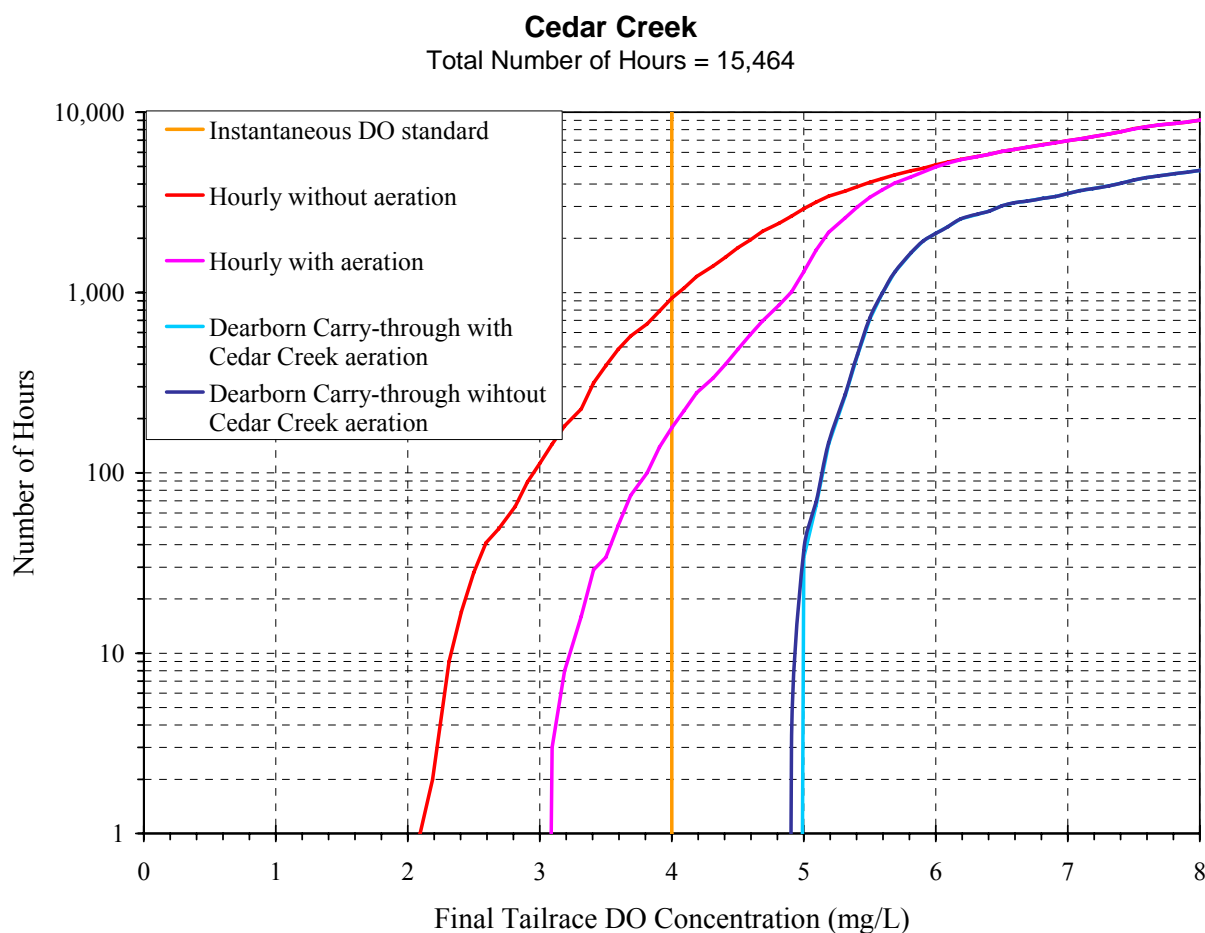
The DBM was calibrated in 2006 for the one of the Cedar Creek HVR turbines and the EVB turbine. The field calibration test included the following measurements at various unit power levels: airflow, water flow, initial DO flowing to the turbine, temperature, and DO uptake. The calibrated DBM for the turbines was used as a tool to predict the DO uptake of the existing turbines by solving the calibrated equation with historical hourly flows, temperatures, and DO concentrations. These historical mean hourly values were calculated from the long period of record of water quality measurements made in the tailrace at 5-minute intervals.

Similar to Dearborn, even without aeration, Cedar Creek had a relative high compliance of 94.9 percent (Figure 29) to the instantaneous 4.0 mg/l standard. However, compliance with the daily average standard of 5.0 mg/l was only 75.4 percent of the days (Figure 30). Turbine venting increased the compliance with 92 percent for the 4.0 mg/l instantaneous standard and 91.2 percent of the days complying with the daily average of 5.0 mg/l.

**FIGURE 29**  
**FREQUENCY OF COMPLIANCE WITH INSTANTANEOUS DISSOLVED OXYGEN**  
**STATE WATER QUALITY STANDARDS (4.0 MG/L) FOR HOURLY DISSOLVED**  
**OXYGEN CONCENTRATIONS AT THE CEDAR CREEK DEVELOPMENT –**  
**CALCULATED FROM DISCRETE BUBBLE MODEL IN COMPARISON TO THE**  
**HISTORICAL RECORD**



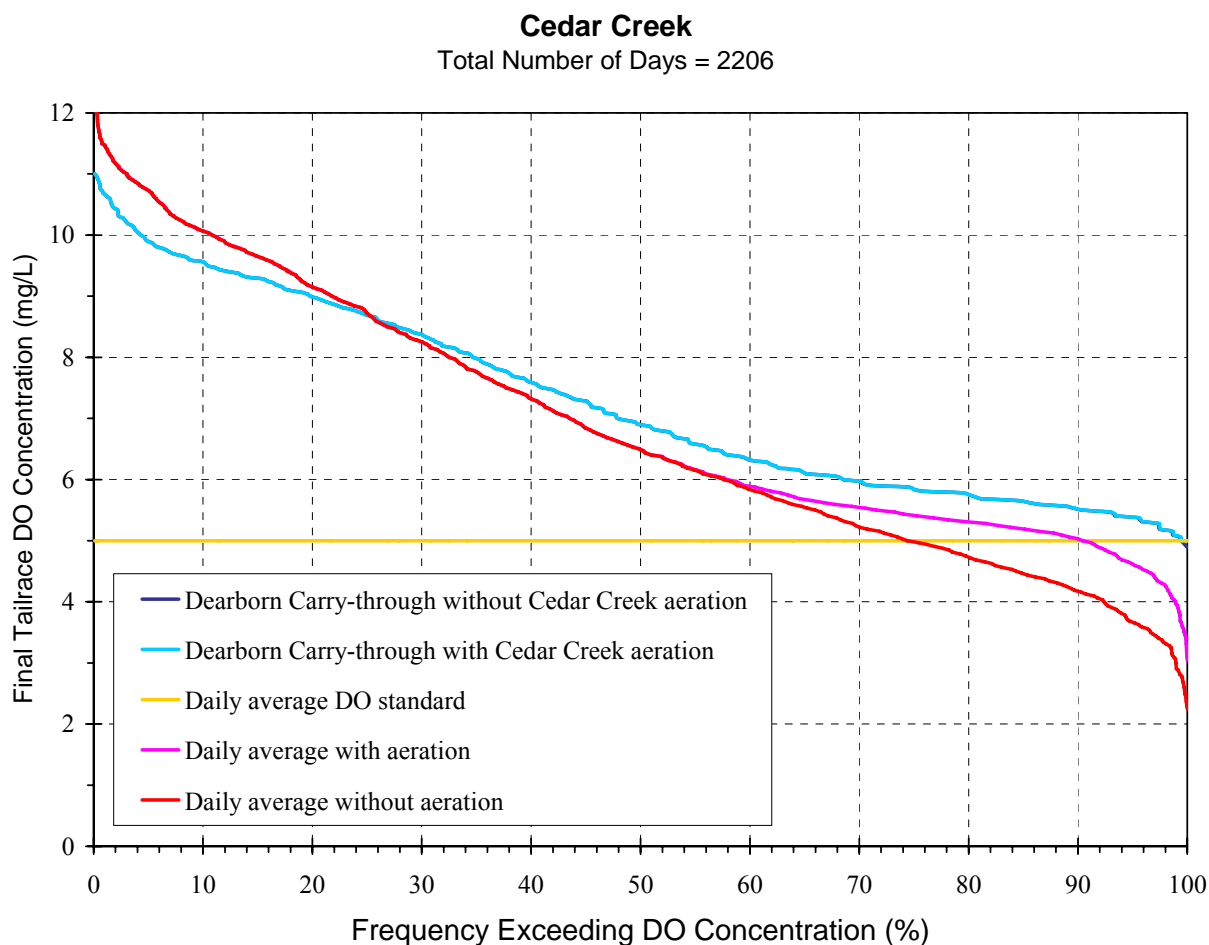
**FIGURE 30**  
**COMPARISON OF HOURS OF NON-COMPLIANCE AT THE CEDAR CREEK DEVELOPMENT TO INSTANTANEOUS DISSOLVED OXYGEN STATE WATER QUALITY STANDARDS (4.0 MG/L) CALCULATED FROM DISCRETE BUBBLE MODEL AND THE HISTORICAL RECORD**



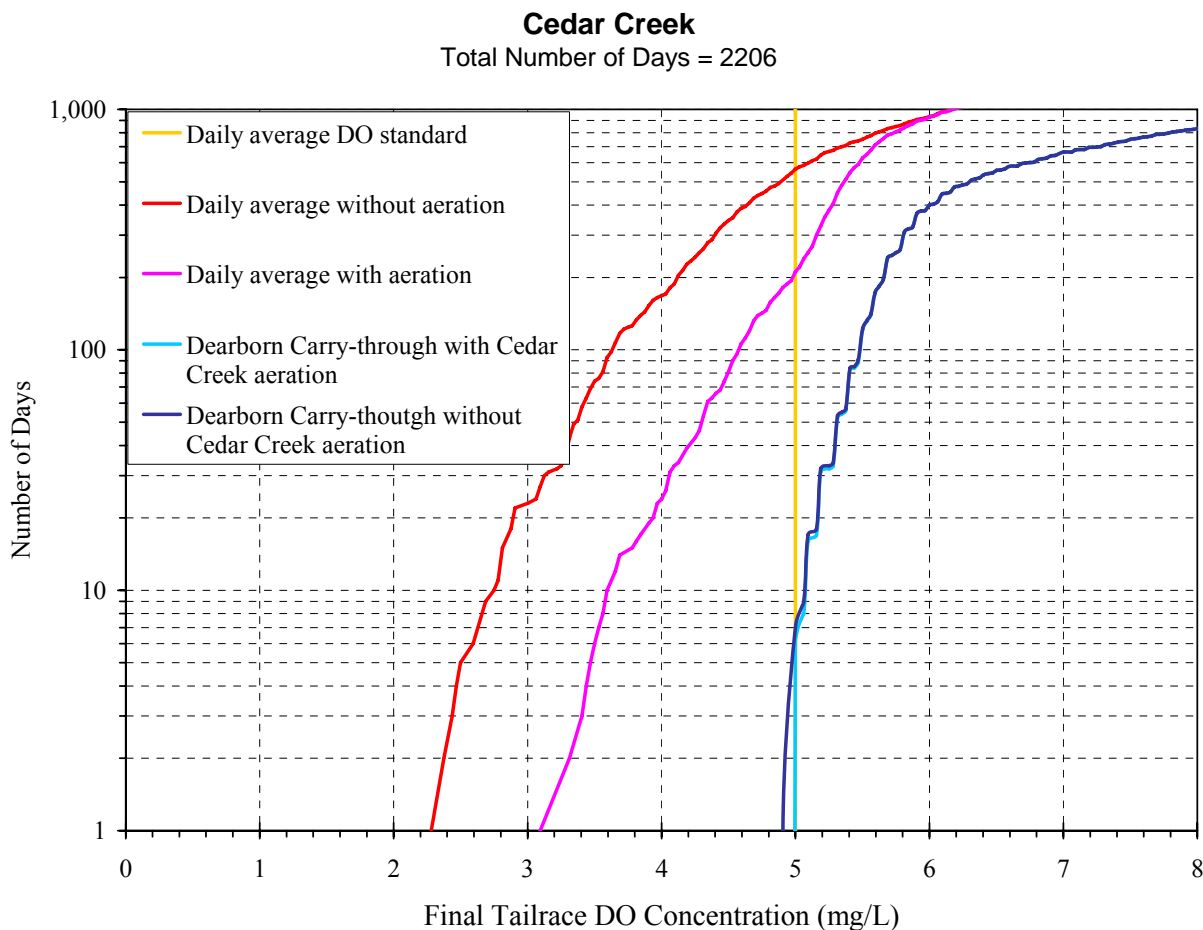
Of special interest for the Cedar Creek Development is the impact of both Dearborn and Fishing Creek on the future DO concentrations in the water for Cedar Creek generation. Similar to Dearborn, the retention time of Cedar Creek Reservoir is extremely short. Also, significantly decreasing the effective retention time is the Great Falls Long Bypassed Reach, which acts as a direct flow path from Dearborn to Cedar Creek bypassing most of the Great Falls Reservoir. In order to simulate the future conditions of Cedar Creek generation (especially since Cedar Creek is used in tandem with Dearborn and Fishing Creek), a 6-hour running average of the DO of Dearborn's aerated releases was used as Cedar Creek's turbine inflow DO. These adjusted DO

values simulate a very conservative contribution of DO from the two upstream hydros. (These estimates conservatively do not account for the additional aerated inflow from the Great Falls Long Bypassed Reach). Even without aeration at Cedar Creek, the impact of aeration at Dearborn and Fishing Creek significantly increases compliance at Cedar Creek to 100 percent for the 4.0 mg/l standard and 99.5 percent to the 5 ml daily average (Figures 31 and 32). The cumulative benefit of the two upstream hydros and from Cedar Creek's turbine venting resulted in 100 percent compliance with both standards.

**FIGURE 31**  
**FREQUENCY OF COMPLIANCE WITH DAILY AVERAGE DISSOLVED OXYGEN**  
**STATE WATER QUALITY STANDARDS (5.0 MG/L) FOR DAILY AVERAGE**  
**DISSOLVED OXYGEN CONCENTRATIONS AT THE CEDAR CREEK**  
**DEVELOPMENT – CALCULATED FROM DISCRETE BUBBLE MODEL IN**  
**COMPARISON TO THE HISTORICAL RECORD**



**FIGURE 32**  
**COMPARISON OF DAYS OF NON-COMPLIANCE AT THE CEDAR CREEK**  
**DEVELOPMENT TO DAILY AVERAGE DISSOLVED OXYGEN STATE WATER**  
**QUALITY STANDARDS (5.0 MG/L) CALCULATED FROM DISCRETE BUBBLE**  
**MODEL AND THE HISTORICAL RECORD**



#### 5.4.4.2 Resource Enhancement – Existing Use Standards

According to the South Carolina Department of Health and Environmental Control (SCDHEC) Regulation 61-68: Water Classifications and Standards for South Carolina Waters (2004): it is the goal of SCDHEC “to maintain and improve all surface waters to a level that provides for the survival and propagation of a balanced indigenous aquatic community of fauna and flora. These narrative criteria are determined by the Department based on the condition of the waters of the

*State by measurements of physical, chemical, and biological characteristics of the waters according to their classified uses.”* This existing use water quality standard addresses the need for any receiving waters to be of suitable quality to provide for appropriate aquatic communities.

At “lake-to-lake” tailraces (Rhodhiss, Cowans Ford, Mountain Island, Fishing Creek, Great Falls-Dearborn, and Rocky Creek-Cedar Creek), the downstream reservoir backs up into the powerhouse tailrace. At these lake-to-lake locations, the tailwater character will remain lacustrine in nature and would not reasonably be expected to change in nature under minimum continuous flows that are more appropriately intended to enhance riverine aquatic habitat. However, the reservoir headwater in the vicinity of the hydro tailrace may benefit from DO enhancements.

Based on known aquatic resources and the anticipated improvements in DO levels in the Cedar Creek tailrace Cedar Creek Development will comply with the SCDHEC narrative water quality standard.

## **5.5 Wateree Development**

The Wateree Development consists of the following existing facilities: (1) the Wateree Dam consisting of: (a) a 1,450-foot-long uncontrolled concrete gravity ogee spillway; and (b) a 1,370-foot-long earth embankment; (2) a 13,025-acre reservoir with a normal water surface elevation of 225.5 feet above msl; (3) a powerhouse integral to the dam, situated between the spillway and the earth embankment, containing five vertical Francis-type turbines directly connected to five generators, two rated at 17,100 kW and three rated at 18,050 kW for a total installed capacity of 82.0 MW; and (4) other appurtenances (Figure 33).

### 5.5.1 Current Status

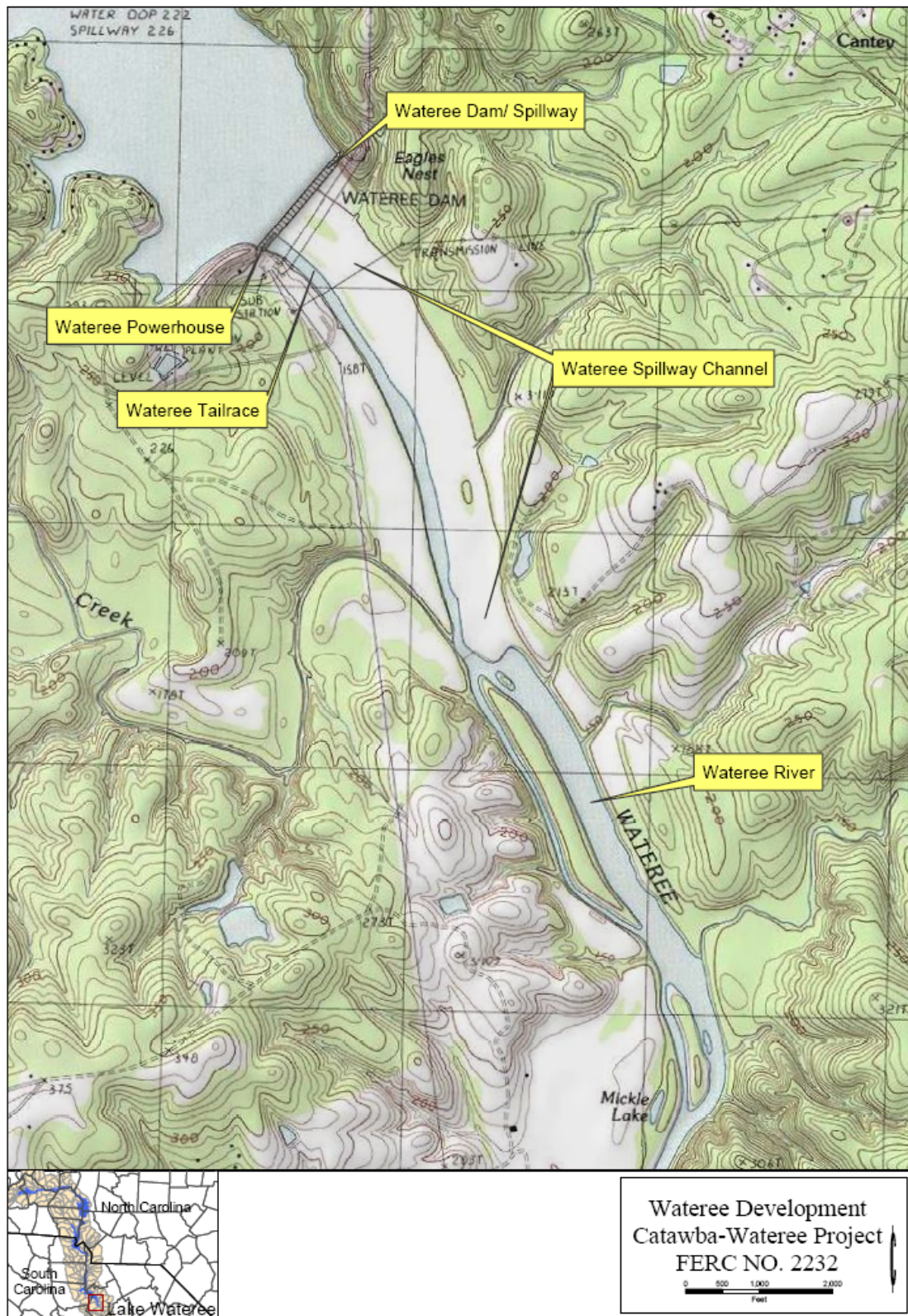
#### 5.5.1.1 South Carolina DHEC Assessments and Water Quality Standards

Six of the eight locations sampled by SCDHEC (2005) in Lake Wateree were impaired for aquatic life, but all fully supported recreation. The upper portion of the lake exhibited high total phosphorus, turbidity, and Chlorophyll a and lower pH values. Total suspended solids were reported to be increasing. The middle to lower part of the lake exhibited fewer water quality excursions from standards and, at two locations fully supported aquatic life.

Impaired waters inside the project boundaries include:

- Wateree Reservoir: 6 locations, aquatic life impairment (total phosphorus, pH, turbidity and Chlorophyll a)

**FIGURE 33**  
**WATEREE DEVELOPMENT**



Impaired waters outside the project boundaries that potentially influence water quality within the project include:

- South Carolina 303(d) listings for inflows to Wateree Reservoir were:
  - Little Wateree Creek watershed: 1 location, recreation and aquatic life impairment, (fecal coliforms and DO)
  - Big Wateree Creek watershed: 1 location, recreation and aquatic life impairment, (fecal coliforms and DO)
  - Dutchman’s Creek watershed: 1 location, recreation (fecal coliforms)
- South Carolina 303(d) listings downstream of the Wateree Development were:
  - Wateree River below Wateree Dam – fish (mercury )
  - Wateree River at Highway 1 – aquatic life (DO)
  - Wateree River at I-20 - aquatic life (DO), fish (mercury)
- South Carolina 303(d) listings for inflows to Wateree River downstream of the Wateree Development were:
  - Grannies Quarter Creek – recreation and aquatic life impairment, (fecal coliforms and pH)
  - Twenty Five Mile Creek – recreation and aquatic life impairment, (fecal coliforms and bioassessment)

#### 5.5.1.2 FERC Relicensing Data Summary

### **Reservoir – Lake Wateree**

#### Water Quality Findings

- Lake Wateree has a moderate retention time (27 days on average). Most of the flow entering Lake Wateree comes from the Cedar Creek Development.

- Duke Energy operates the Wateree Development for peaking energy, maintenance of target lake levels, and downstream water use.
- Stratification is weak to moderate but stable for the most part.
- SCDHEC lists Lake Wateree as impaired due to high total phosphorus, Chlorophyll *a*, and pH.
- Wateree Reservoir receives high concentrations of nutrients and organic matter and low concentrations of DO from the Cedar Creek-Rocky Creek Project. Since Fishing Creek, Great Falls, and Cedar Creek Reservoirs have very short retention times with limited internal processing of pollutant loads, the majority of the nutrient loads to Lake Wateree originate upstream of Fishing Creek Reservoir.
  - Total phosphorus in the inflows to Wateree is over 3 times greater than the SCDHEC water quality standard and 6 times greater than the TP level in the Wylie releases.
  - Organic matter entering Wateree is almost 5 times greater than that discharged from Wylie Reservoir.
  - Pollutant loads cause high algae concentrations, producing even more organic matter, and low DO in Wateree Lake.
  - Wateree Lake traps about 50 percent of the TP entering the reservoir through sedimentation and biological processing.
- DO concentrations throughout much of the reservoir periodically can be less than 5.0 mg/l. Concentrations of DO less than 4.0 mg/l periodically can occur at the surface of the lake in some parts of the reservoir. These low DO conditions occur in the reservoir because of high DO demands in the lake that are caused by organic matter in the reservoir that comes from the upstream watershed as well as algae that grow in the lake.
- Algae concentrations in the lake sometimes exceed 50 ug Chlorophyll *a*/l, which is greater than the SCDHEC standard of 40 ug Chlorophyll *a*/l.
- BOD5 values in the river upstream from Fishing Creek Reservoir are 2 to 3 times normal levels (based on USGS and SCDHEC data). When a lake has such high DO demands in the water, it is susceptible to episodes of low DO throughout the water column following inevitable mixing events caused by windy and/or cool weather conditions.

### Biological Resource Findings

The following information on the biological resources of Lake Wateree was provided in Book 2 of 10, Application for New License Supplement and Clarification - Aquatics 01 Study Report (Duke Energy 2007):

- Thirty species of fish, plus hybrid sunfish, were observed during spring shoreline electrofishing (1994–1997; 2000). Two areas were sampled: an uplake region just upstream of the Dutchman’s Creek confluence; and a region farther downlake, just upstream of the White Oak Creek confluence. Total littoral fish biomass averaged 80.7 kg/km in the uplake area and 165.2 kg/km in the downlake area.
- Taxonomic composition of the littoral fish community was generally similar in the two regions of Lake Wateree. Based on data from both areas, common carp accounted for 42 percent of total biomass on average, largemouth bass 31 percent, sunfish (primarily bluegill) 8 percent, and gizzard shad 7 percent.
- In terms of density, the littoral community was dominated by sunfish (primarily bluegill), which accounted for 37 percent of total fish numbers on average, and gizzard and threadfin shad, which together accounted for an average of 35 percent of total fish density.
- Hydroacoustic sampling (1997 and 2000) indicated the limnetic forage fish densities in Lake Wateree were 7,402 fish per hectare in 1997 and 51,102 fish per hectare in 2000.
- Purse seine sampling (1993–1997; 2000) indicated that threadfin shad constituted from 80.0 to 99.9 percent of the limnetic forage fish community while gizzard shad averaged 5.7 percent.
- Fish kill data for Lake Wateree indicate that winter kills of threadfin shad were occasionally reported during the 1970s and 1980s. Winter water temperatures on Lake Wateree averaged 8.6°C, which is just below the threshold at which threadfin shad experience thermal stress.

**Wateree Regulated River Reach****Water Quality Findings**

- Ten years of tailrace continuous monitoring at  $\approx$  5-minute intervals for temperature, pH, and DO revealed that only DO did not meet state water quality standards for turbine releases.
- On the average, during May through November, 31 percent of the hourly average DO concentrations released from the Wateree Development are lower than the current state standard of 4.0 mg/l instantaneous.
- On the average, during May through November, 54 percent of the daily average DO concentrations released from the Wateree Development are lower than the current state standard of 5.0 mg/l daily average.
- Actual 4-year (1997–2000) average nutrient Cedar Creek releases compared to Wateree Releases:
  - Phosphorus – Cedar Creek = 221 mg/l; Wateree = 104 mg/l
  - Dissolved Organics – Cedar Creek = 5.9 mg/l; Wateree = 5.3 mg/l
  - Particulate Organics – Cedar Creek = 9.3 mg/l; Wateree = 4.2 mg/l
- Temperature and DO are very dynamic in the 4-mile section between the Wateree Dam and downstream of Mickle Lake Island (RM 74.0). This rocky, shoaling section of the Wateree River is dominated by a succession of native attached aquatic plants. A groundwater source immediately downstream of Wateree Dam contributes to a lower temperature on the east side of the river.
  - During low flows (leakage and one unit generation), the extensive aquatic plant communities and shoal control DO concentrations, regardless of aeration of the released water.
  - During higher generation flows, DO concentrations downstream reflect the concentrations released from the Wateree Development.
- Downstream of Mickle Lake Island, the river transitions from a shoal dominated system to that of a sandy bottom river.

- At low flows, the temperatures are dominated by the gradual diel heating and cooling cycles as the water moves downstream. DO concentrations are indicative of the organics released from Lake Wateree and the diel cycle of planktonic organisms.
- At higher generation flows, the characteristics of the water released from the Wateree Development are realized further downstream, with temperature and DO changes similar to low flow conditions, but, occurring at a slower rate.

### Biological Resource Findings

The following information on the biological resources of the Wateree Regulated River Reach was provided in Book 2 of 10, Application for New License Supplement and Clarification - Aquatics 01, Aquatics 06, and Aquatics 07 Study Reports (Duke Energy 2007):

- The fish community in the Wateree Regulated River Reach was sampled at five locations. The first location was at RM 1.6 in the vicinity of the Little River tributary, the second location was in the vicinity of Colonels Creek and the Hwy 76 & 378 bridge crossing (RM 25.3), the third location was in the vicinity of the gravel bar just upstream of I-20 (RM 67.1), the fourth location was in the vicinity of the gravel bar and shoal upstream of the Hwy 1 and 601 access area (RM 74.1), and the fifth location was at the immediate tailrace of the dam (RM 76.7).
- The species composition of the fish community at RM 1.6 was typical for the habitat type present in this reach with 30 fish species and 610 individuals being collected over the two sampling periods. Threadfin shad and white perch comprised 44 percent of the total number of individuals collected in the spring sampling period and largemouth bass and gizzard shad comprised 37 percent of the total number of individuals collected in the summer sampling period.
- The species composition of the fish community at RM 25.3 was typical for the habitat type present in this reach with 32 fish species and 625 individuals being collected over the two sampling periods. Threadfin shad and coastal shiner comprised 45 percent of the total number of individuals collected in the spring sampling period and redbreast sunfish and longnose gar comprised 38 percent of the total number of individuals collected in the summer sampling period.

- The species composition of the fish community at RM 67.1 was typical for the habitat type present in this reach with 28 fish species and 909 individuals being collected over the two sampling periods. Threadfin shad and shorthead redhorse comprised 56 percent of the total number of individuals collected in the spring sampling period and redbreast sunfish and white perch comprised 41 percent of the total number of individuals collected in the summer sampling period.
- The species composition of the fish community at RM 74.1 was typical for the habitat type present in this reach with 33 fish species and 1,513 individuals being collected over the two sampling periods. Threadfin shad and longnose gar comprised 71 percent of the total number of individuals collected in the spring sampling period and 22 percent of the total number of individuals collected in the summer sampling period.
- The species composition of the fish community at RM 76.7 was typical for the habitat type present in this reach with 31 fish species and 2,484 individuals being collected over the two sampling periods. Threadfin shad and gizzard shad comprised 91 percent of the total number of individuals collected in the spring sampling period and threadfin shad and longnose gar comprised 59 percent of the total number of individuals collected in the summer sampling period.
- Benthic invertebrate sampling in this reach indicated good populations of macroinvertebrates. Two bioassessment locations were sampled downstream of Wateree Dam. The bioclassifications at Location 1 (nearest Wateree Dam approximately 0.5 kilometers downstream) and Location 2 (approximately 2.5 kilometers downstream) were Fair. There were 7 EPT taxa collected at Location 1, and 8 collected at Location 2. The biotic index scores for the two locations were similar as were the habitat conditions.
- In addition to the fish community discussed above, the Wateree Regulated River Reach also provides habitat for populations of the freshwater mussel species: *Elliptio complanata*, *Elliptio congaraea*, *Elliptio angustata*, *Elliptio roanokensis*, *Unio sp.*, *Ligumia nasuta*, *Utterbackia imbecillis*, *Pyganodon cataracta*, *Lampsilis cariosa*, and *Lampsilis splendidiada*. Other mussel and snail species observed in this area include Asiatic clams (*Corbicula fluminea*), Riverhorn snail (*Elimia catenaria*), Brown mystery snail (*Campeloma decisum*), and Two-ridged Rams-horn (*Helisoma anceps*).

### 5.5.2 Water Quality Issue Identification and Evaluation

Even though the SCDHEC assessment of the Wateree Development waters is deemed compatible with the ascribed designated use, the tailrace and bypassed reaches of this development were not consistently meeting state water quality standards. Therefore, the primary issue dealing with water quality is to protect the water quality where standards were met, and to bring appropriate areas up to state water quality standards.

#### **Wateree Regulated River Reach**

- Establish continuous minimum aquatic habitat flow in Wateree River channel.
- Enhance DO concentrations of water released from powerhouse to meet state standards.

#### **Wateree Bypassed Reach**

- Mitigate for aquatic habitat in dewatered bypass reach that does not fully meet resource agency goals.

### 5.5.3 Project Modifications for Water Quality Compliance and Resource Enhancement

Stakeholder negotiations and engineering evaluations have resulted in the following proposed hydro modifications and lake level operational changes.

**Proposed Engineering Changes**

**TABLE 22**  
**WATEREE DEVELOPMENT AERATION CAPABILITIES**

<b>Turbine/ Other Release Point</b>	<b>Original</b>	<b>Current (as of 12/31/2006)</b>	<b>Future (from FWQIP)</b>
Wateree Unit 1	OVb	AVR	AVR
Wateree Unit 2	OVb	EVB	EVB
Wateree Unit 3	OVb	AVR	AVR
Wateree Unit 4	OVb	EVB	EVB
Wateree Unit 5	OVb	EVB	AVR CMR

OVb = Original Vacuum Breaker - Unimproved original vacuum breaker aeration

EVB = Enhanced Vacuum Breaker - Improved vacuum breaker aeration (modified piping and/or headcover)

AVR = Auto Venting Runner - Auto venting type turbine aeration (new auto venting runner)

CMR = Dedicated continuous minimum flow turbine, valve or modification

For additional details, refer to the FWQIP shown in Table 4 of the 401 Water Quality Application.

In accordance with the Fish Passage Accord negotiated and signed by SCDNR, the USFWS, and Duke, diadromous fish stocking, studies, and passage will be provided at and below the Wateree Development. Please refer to Section 8 and Appendix D of this SIP for more information.

**Proposed Operational Changes****Reservoir – Lake Wateree**

**TABLE 23**  
**TARGET RESERVOIR ELEVATIONS FOR LAKE WATEREE**

Elevation (ft)at start of day	USGS	Datum	Full Pond = 100	
	Existing	Proposed	Existing	Proposed
January 1	220.5	220.0	95.0	94.5
February 1*	220.5	220.5	95.0	95.0
March 1**	222.5	222.5	97.0	97.0
April 1	222.5	222.5	97.0	97.0
May 1	222.5	222.5	97.0	97.0
June 1	222.5	222.5	97.0	97.0
July 1	222.5	222.5	97.0	97.0
August 1	222.5	222.5	97.0	97.0
September 1	222.5	222.5	97.0	97.0
October 1	222.5	222.5	97.0	97.0
November 1	222.5	222.5	97.0	97.0
December 1***	220.5	220.5	95.0	95.0

\*This date is January 25 for existing normal target elevations.

\*\*This date is February 17 for existing normal target elevations.

\*\*\*This date is December 14 for existing normal target elevations.

- Minimum Habitat Continuous Flows - The following habitat flows for the Project from the CRA are based on study results, stakeholder negotiations and CHEOPS analysis of flow levels that provided improved aquatic habitat, balanced other water user interests, and which were at levels, which could be sustained over the life of the New License.

**TABLE 24**  
**MINIMUM RELEASE REQUIREMENTS FOR THE WATEREE DEVELOPMENT**

Flow (cfs) for month	MADF Release		Continuous Release	
	Existing	Proposed	Existing	Proposed
January	446	0	0	930
February*	446	0	0	930
February 15	446	0	0	2,400
March	446	0	0	2,700
April	446	0	0	2,700
May**	446	0	0	2,400
May 16	446	0	0	1,250
June	446	0	0	930
July	446	0	0	930
August	446	0	0	930
September	446	0	0	930
October	446	0	0	930
November	446	0	0	930
December	446	0	0	930

\*Minimum release increases from 930 to 2,400 cfs on February 15.

\*\*Minimum release decreases from 2,400 to 1,250 on May 16.

#### 5.5.4 Reasonable Assurance of Future Compliance and Resource Enhancement

##### 5.5.4.1 Dissolved Oxygen - Numeric Standards

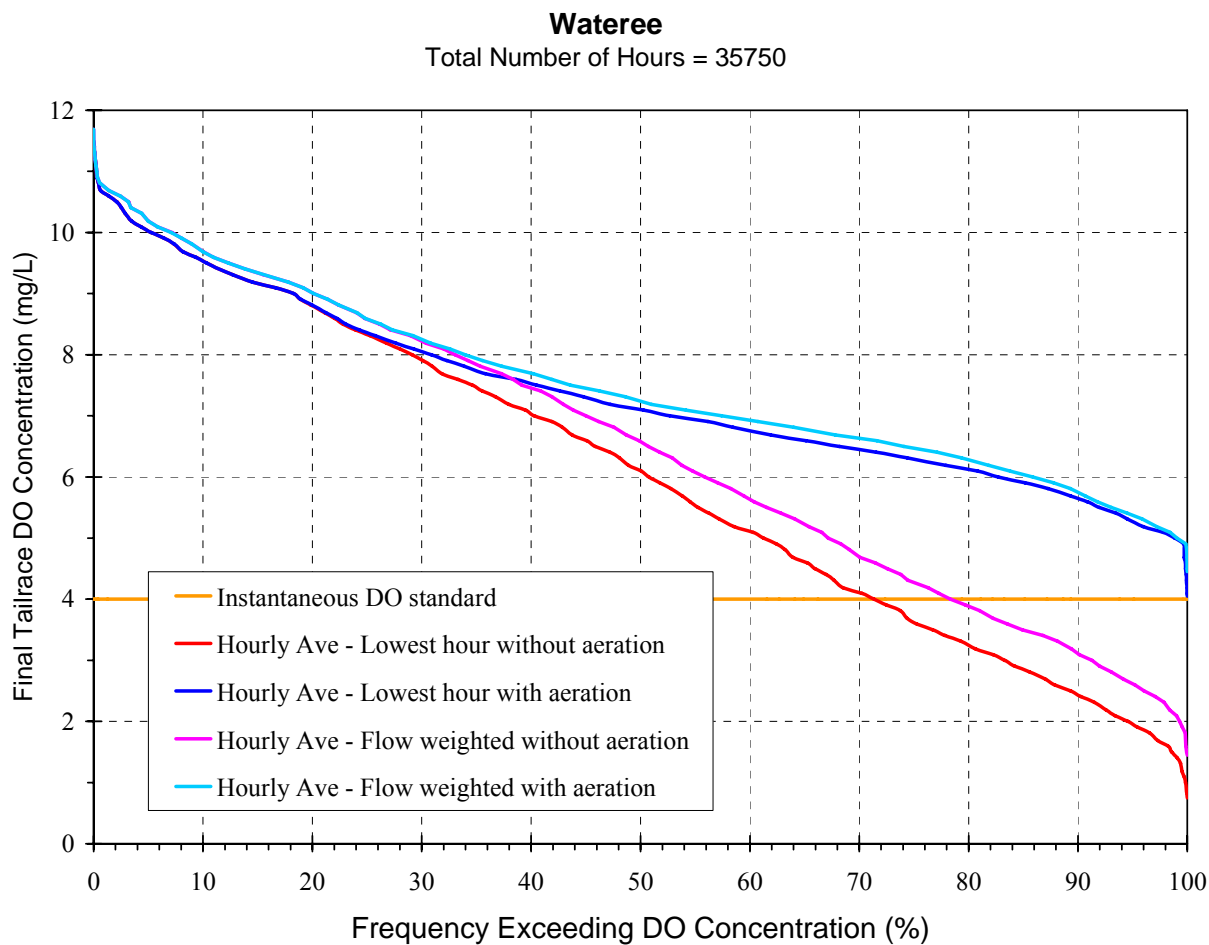
The applicability of turbine venting to the Wateree Development was evaluated by developing a DBM (Appendix C) for each turbine configuration (Wateree = 2 EVB units and 3 AVR units).

The DBM was calibrated in 2002 for each type of turbine. The field calibration test included the following measurements at various unit power levels: air flow, water flow, initial DO flowing to the turbine, temperature, and DO uptake. The calibrated DBM for each turbine was used as a tool to predict the DO uptake and future tailrace oxygen conditions by applying the DBM equation to the data from the record of water quality measurements made at 5-minute intervals in the Wateree tailrace.

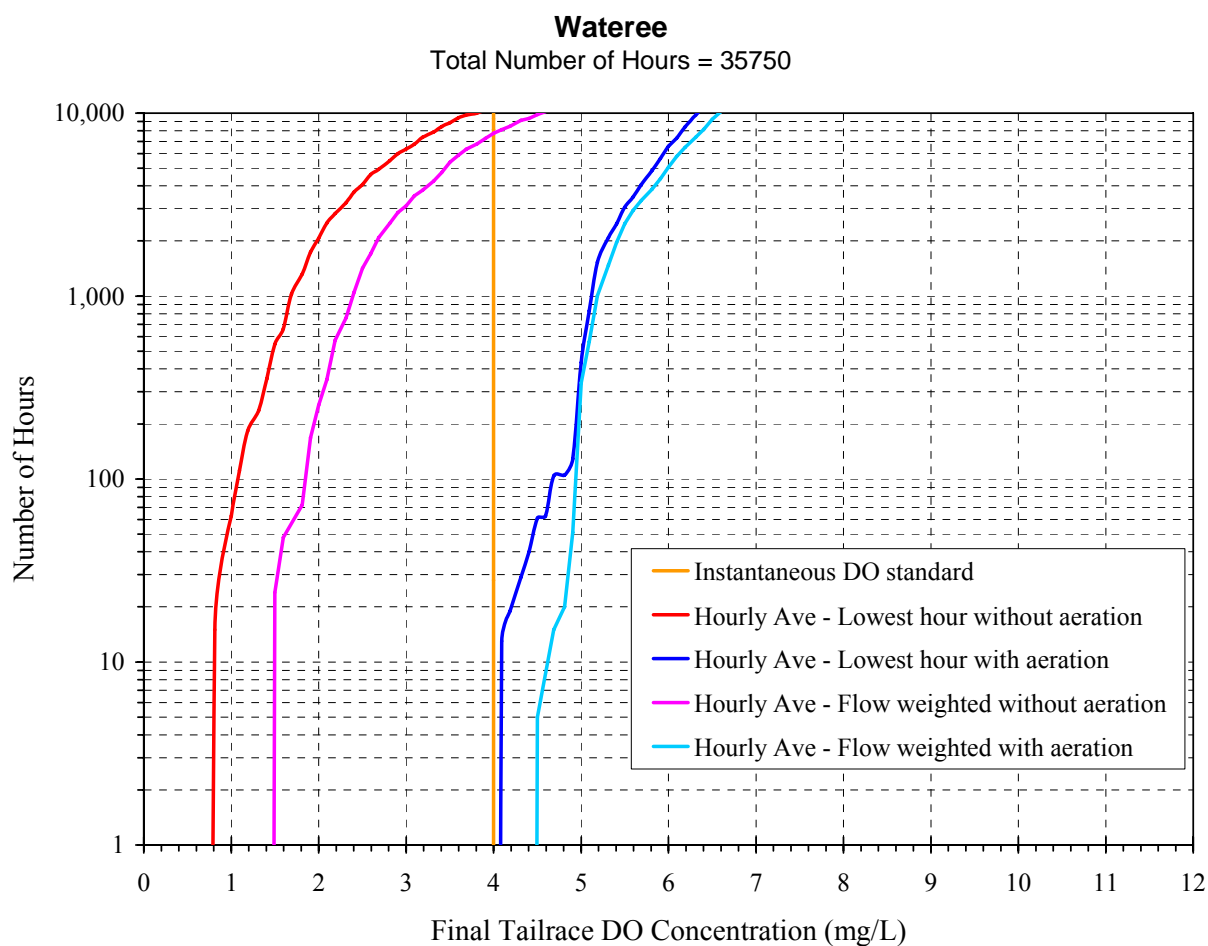
Since future operations require a continuous minimum flow specified by the CRA, the application of the DBM required that all historical continuous flows be no lower than the new minimum flow (930 cfs). The amount of water used for continuous minimum flow was subtracted from the daily generation and the remaining water was analyzed as generation flow through the DBM model. Additionally, the DO applied to the water flowing into the turbine had to be adjusted for the new flows. These conservative DO adjustments were (1) apply the lowest daily DO observed and applied to all flows, and (2) historical daily flow weighted DO. These values were applied to all flows for that day. (See Section 4.2.1 for a complete description of the methodology). The resulting predictions made from the DBM were compared to the actual historical monitoring data.

Of the 35,750 hours used from the historical monitoring data, 72.5 percent of the minimum daily DO values and 79.7 percent of the flow weighted DO concentrations were greater than the instantaneous DO standard of 4.0 mg/l prior to aeration (Figure 34). These percentages corresponded to 10,479 and 7,261 total hours, respectively (Figure 35). If the CRA flows had been in place and the new turbine configuration operable, the DO concentrations in the tailrace would have drastically improved to greater than 100 percent compliance with either of the two inflowing DO values (Figure 35).

**FIGURE 34**  
**FREQUENCY OF COMPLIANCE WITH INSTANTANEOUS DISSOLVED OXYGEN**  
**STATE WATER QUALITY STANDARDS (4.0 MG/L) FOR HOURLY DISSOLVED**  
**OXYGEN CONCENTRATIONS AT THE WATEREE DEVELOPMENT –**  
**CALCULATED FROM DISCRETE BUBBLE MODEL IN COMPARISON TO THE**  
**HISTORICAL RECORD**

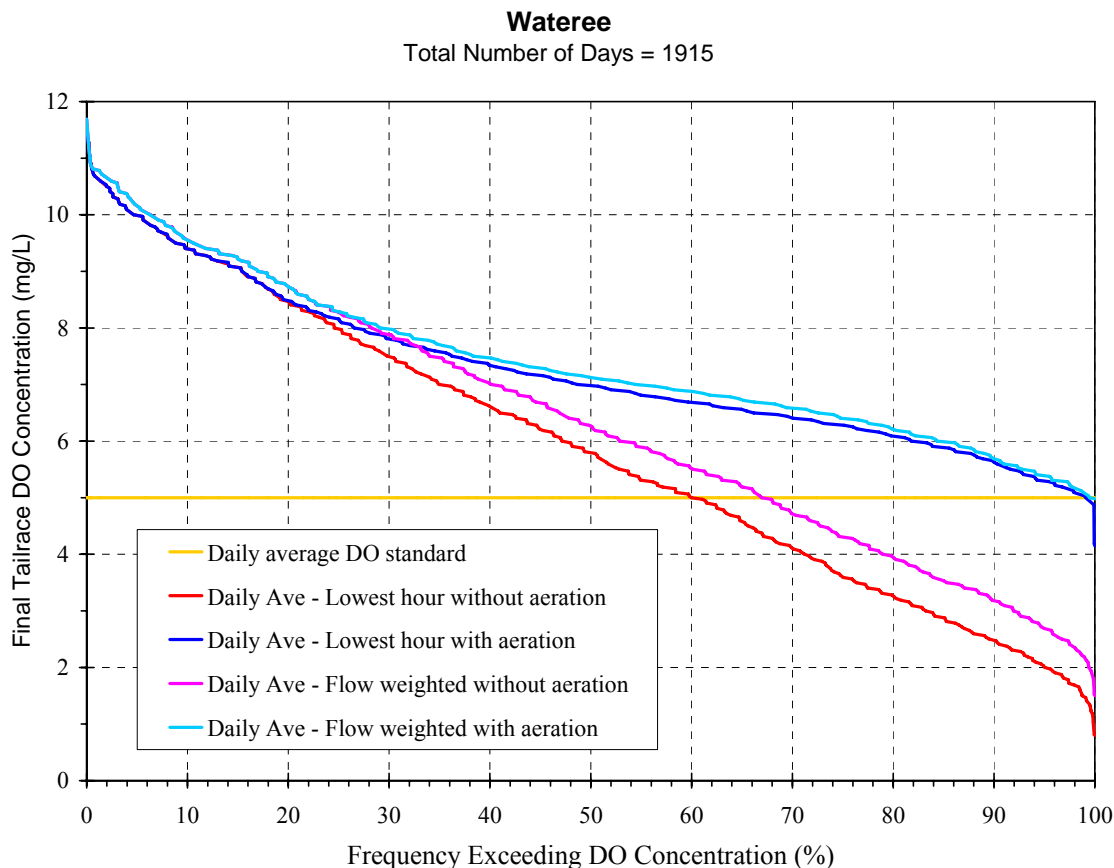


**FIGURE 35**  
**COMPARISON OF HOURS OF NON-COMPLIANCE AT THE WATEREE**  
**DEVELOPMENT TO INSTANTANEOUS DISSOLVED OXYGEN STATE WATER**  
**QUALITY STANDARDS (4.0 MG/L) CALCULATED FROM DISCRETE BUBBLE**  
**MODEL AND THE HISTORICAL RECORD**

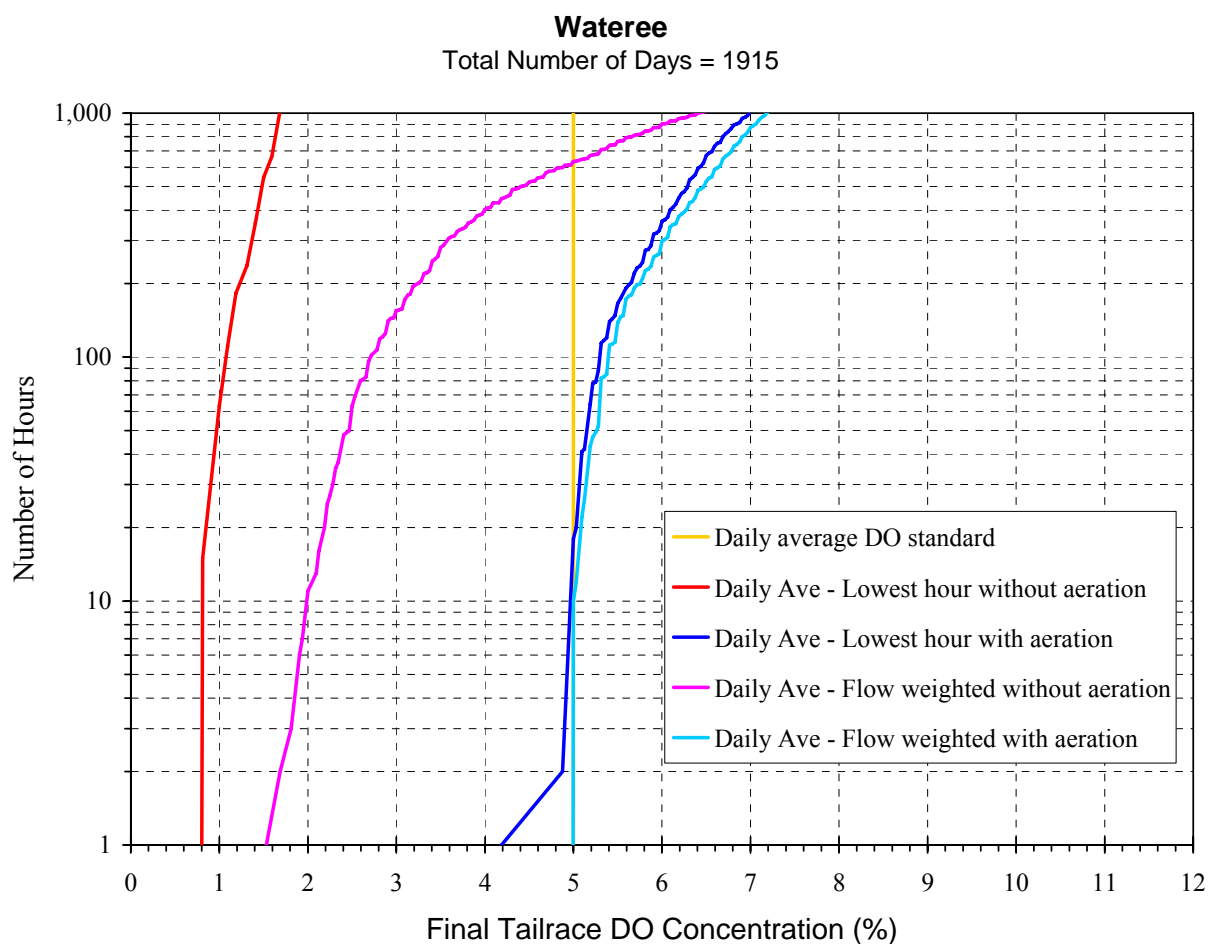


When the daily average DO concentrations were calculated from the hourly DO values, the percentage of compliance with the 5.0 mg/l prior to turbine venting was 61.1 percent for the minimum daily DO method and 67.9 percent for the flow-weighted average method (Figure 36). The total days of non-compliance would have been 771 and 614, respectively (Figure 37). Using the same historical database with 1,915 days of data, but applying the CRA minimum flows and turbine venting, the compliance with the daily average DO standard of 5.0 mg/l would have been 100 percent (Figure 36) with no days exhibiting a daily average of less than 5.0 mg/l (Figure 37).

**FIGURE 36**  
**FREQUENCY OF COMPLIANCE WITH DAILY AVERAGE DISSOLVED OXYGEN**  
**STATE WATER QUALITY STANDARDS (5.0 MG/L) FOR DAILY AVERAGE**  
**DISSOLVED OXYGEN CONCENTRATIONS AT THE WATEREE DEVELOPMENT –**  
**CALCULATED FROM DISCRETE BUBBLE MODEL IN COMPARISON TO THE**  
**HISTORICAL RECORD**



**FIGURE 37**  
**COMPARISON OF DAYS OF NON-COMPLIANCE AT THE WATEREE**  
**DEVELOPMENT TO DAILY AVERAGE DISSOLVED OXYGEN STATE WATER**  
**QUALITY STANDARDS (5.0 MG/L) CALCULATED FROM DISCRETE BUBBLE**  
**MODEL AND THE HISTORICAL RECORD**



#### 5.5.4.2 Resource Enhancement – Existing Use Standards

According to the South Carolina Department of Health and Environmental Control (SCDHEC) Regulation 61-68: Water Classifications and Standards for South Carolina Waters (2004): it is the goal of SCDHEC “to maintain and improve all surface waters to a level that provides for the survival and propagation of a balanced indigenous aquatic community of fauna and flora. These narrative criteria are determined by the Department based on the condition of the waters of the State by measurements of physical, chemical, and biological characteristics of the waters

*according to their classified uses.”* This existing use water quality standard addresses the need for any receiving waters to be of suitable quality to provide for appropriate aquatic communities. As previously described the Wateree Development consists of an impoundment (Lake Wateree) which releases into the regulated river reach downstream. Negotiations with stakeholders indicated that in addition to meeting water quality standards for DO the primary management objectives for the Wateree Development included:

- Warmwater fishery and freshwater mussel habitat enhancement
- Diadromous fish habitat enhancements
- Increased flow in the original river channel below the Wateree Spillway

The allocation of the water resources of the Wateree Development was based on water quality, flow/habitat analyses, and negotiation of releases appropriate for addressing the above resource enhancement goals. These analyses and negotiations lead to the flows for habitat reported in the previous section (Table 25).

The continuous minimum flow agreement for the Wateree Development in the CRA fully meets habitat goals for the Wateree Regulated River Reach. These releases will provide considerable habitat gains and a proposed condition in a New License at Wateree that would be sustainable for the long term and fully meets the SCDHEC Narrative Water Quality Standard.

Duke has agreed to provide continuous flow releases including significantly higher continuous minimum flows during diadromous fish spawning seasons (reference Table 24). These flows will significantly increase habitat for all species/lifestages. In addition, Duke will invest millions of dollars to replace an existing unit with a smaller unit sized to operate at the continuous minimum flow. Delivering the continuous minimum flow without pulsing a unit gains an extra 7 miles of suitable river habitat. Therefore, no mitigation needs were identified for powerhouse releases; however, mitigation for spillway channel habitat not fully meeting resource agency goals is provided (reference Section 6 [Flow Mitigation Package] of this SIP).

#### 5.5.4.3 Use of Water Quality Modeling to Evaluate Proposed Project Modifications

Please refer to Section 7.2 (Assessments of Operational Scenarios).

**TABLE 25**  
**CRA FLOWS: GAINS EXPRESSED AS PERCENTAGE OF UNREGULATED INDEX C FLOWS**  
**AT THE WATEREE DEVELOPMENT\***

Fish Species/Lifestage and/or Guild							
Month	American Shad Spawning (2)	Sturgeon Spawning and Incubation	Golden Redhorse Adult	Deep Fast Adult – Coarse Mixed Substrate (i.e. shorthead redhorse)	Deep Fast Adult – Fine Substrate (i.e. Silver redhorse)	Striped Bass Spawning	Deep Fast Spawning – Gravel Cobble Substrate (i.e. white bass)
January	NA	NA	69.4%	138.7%	173.9%	NA	484.2%
February	NA	33.7%	82.7%	173.7%	157.9%	NA	584.8%
March	257.7%	71.4%	93.0%	208.9%	118.3%	NA	552.5%
April	192.0%	75.3%	95.3%	174.3%	121.4%	80.9%	364.9%
May	142.7%	42.7%	87.8%	138.3%	164.6%	55.4%	364.4%
June	NA	NA	72.0%	107.3%	167.7%	18.7%	255.2%
July	NA	NA	73.4%	97.2%	166.5%	NA	195.6%
August	NA	NA	75.2%	100.1%	165.9%	NA	202.4%
September	NA	NA	75.1%	96.7%	161.3%	NA	184.1%
October	NA	NA	78.3%	99.8%	158.2%	NA	180.8%
November	NA	NA	74.2%	99.8%	165.1%	NA	199.0%
December	NA	NA	69.6%	109.8%	167.6%	NA	282.7%

\* Resource Agency goals met with powerhouse releases in the tailrace; no mitigation provided. Mitigation for spillway channel habitat is being provided (reference Section 6 [Flow Mitigation Package] of this SIP).

## Section 6

# Flow Mitigation Package

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### Flow Mitigation in SC for the Catawba-Wateree Hydroelectric Project

The Aquatics Resource Committee developed continuous minimum flow releases to support and enhance aquatic habitat needs. The methodology employed and processes are thoroughly described in Section 5.6 of the CRA Explanatory Statement and in the Protection, Mitigation, and Enhancement (PM&E) Measures Module found in the License Application. At the conclusion of this process, flows in the following stream and river segments were identified as not fully meeting resource agency resource objectives and, therefore, mitigation is being provided.

- Wylie Regulated River Reach: Duke has agreed to provide for a 1,100 cfs year-round release unless the HIP is invoked which provides even higher flows. These flows will meet unregulated habitat targets for all species/lifestages except Sturgeon and Striper Spawning. Aquatic habitat for both Sturgeon and Striper Spawning will increase significantly under these flows from the current conditions of <1 percent compared to unregulated habitat to 31 percent and 24 percent, respectively. In addition, the minimum flow will be delivered without pulsing a unit which gains an extra 5 miles of suitable river habitat. Therefore, no mitigation needs were identified.
- Great Falls Long Bypassed Reach: The Mutual Gains scenario provides 450 cfs (May 16 through February 14) and 850 cfs (February 15 through May 15). During one of the Aquatics meetings, it was stated that the SCDNR would like to see 90 percent of the GF Long Bypassed Reach wetted. The total length of the Long Bypassed Channel is 2 miles.

Flows and their associated wetted area (based on area wetted at 2,000 cfs – maximum modeling range) are as follows:

- 450 cfs provides 77 percent wetted area for 9 months/year
- 850 cfs provides 87 percent wetted area for 3 months/year
- 550 cfs (average annual) provides 79 percent wetted area

- Goal: 90 percent wetted area year round
  - CRA flows: 79 percent wetted area provided on average
  - Potential Mitigation Needs: 2 miles of impacted reach  $\times$  11 percent (90 percent-79 percent) = 0.22 mile of stream to mitigate.
- Wateree Spillway Channel: There are currently no plans to increase flows in the Wateree Spillway Channel (note that portions of the Spillway Channel are inundated as units at the Wateree Development are brought on-line). The Spillway Channel is 0.4 mile long. The entire 0.4 mile was identified as needing mitigation.

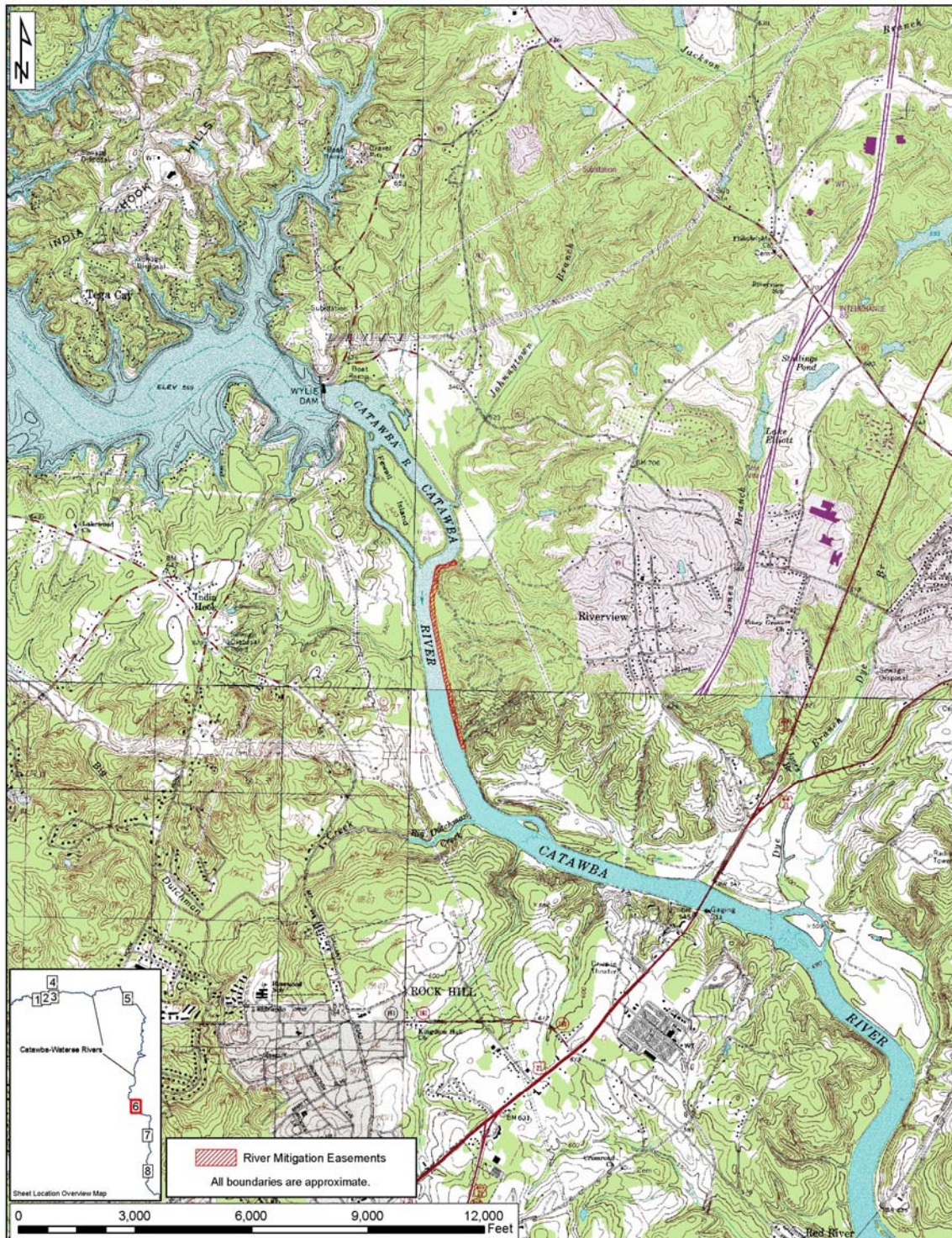
In consultation with the SCDNR and the SCDHEC, Duke proposed to conserve 100-foot-wide buffers along streams consistent with both the North Carolina Department of Natural Resources' (NCDENR) "Stream Mitigation for FERC-related 401 Certifications Internal DWQ Guidance" (January 9, 2006) and the US Army Corps of Engineers stream mitigation guidelines. As all of the mitigation sites in South Carolina were on the mainstem of the river, all the conservation easements are also along the river. Consistent with the discussion above, a mitigation ratio of 4:1 was used to determine the amount of buffer needed as follows:

- Miles of impacted river: 0.22 mile + 0.4 mile = 0.62 mile
- Total miles of credit needed: 0.62 mile  $\times$  4 = 2.48 miles (or 4.96 bank miles)

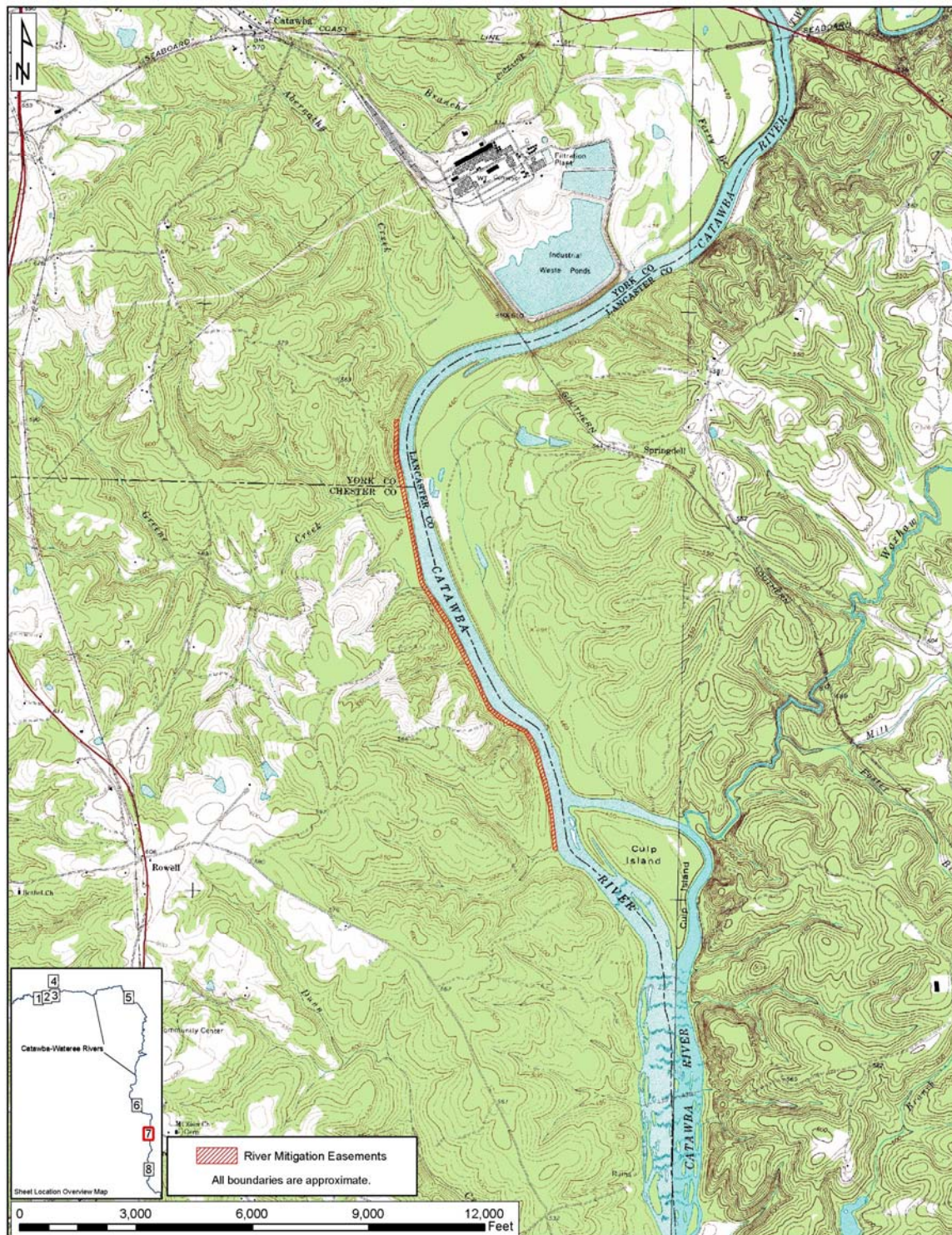
Duke has acquired 5.5 bank miles of 100-foot-wide conservation easements along the Catawba River. Of this total, Duke has already assigned 2 miles of these conservation easements to the SCDNR.

Figures 38 through 40 depict river and stream shoreline easements used for flow mitigation purposes on the Project.

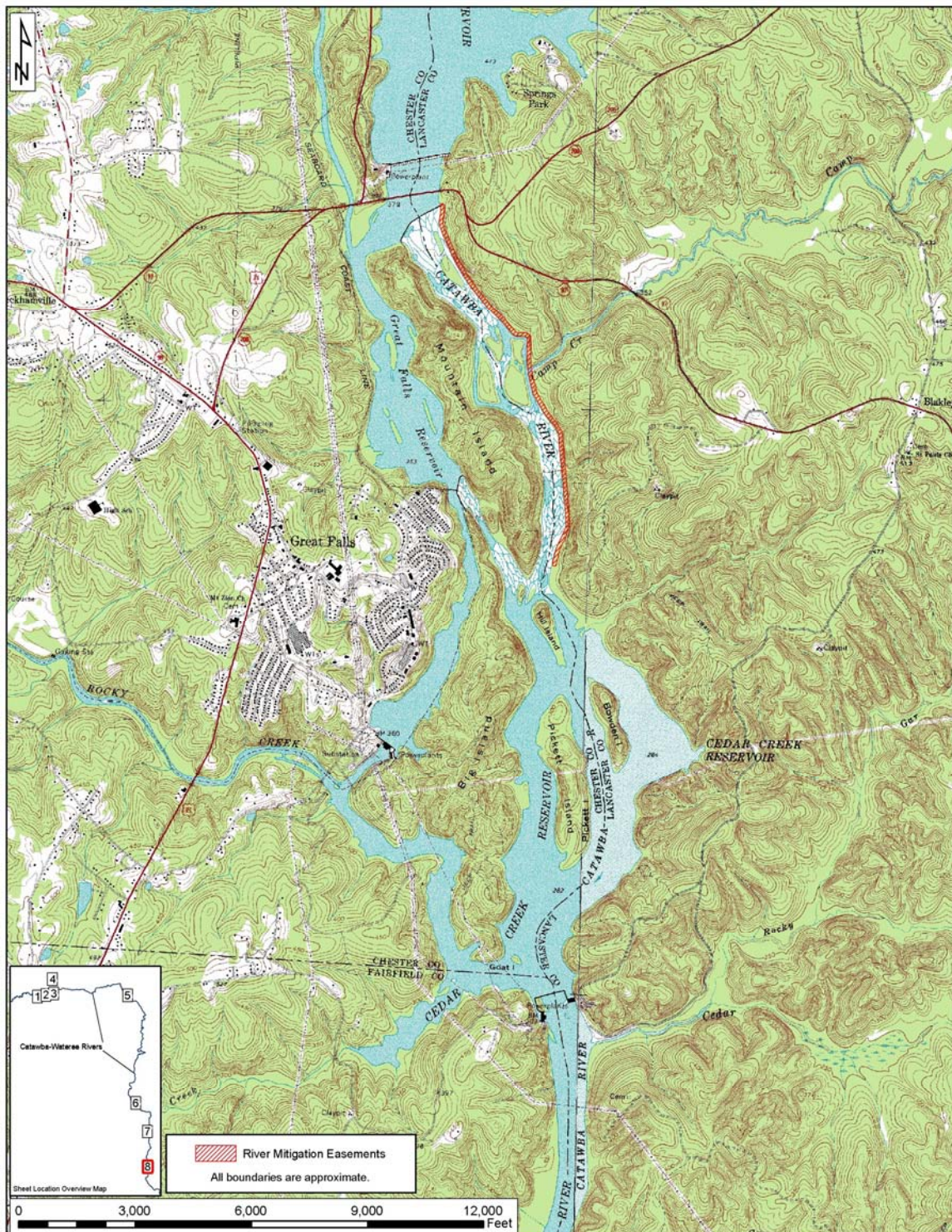
**FIGURE 38**  
**EASEMENTS ON THE CATAWBA RIVER USED FOR FLOW MITIGATION**



**FIGURE 39**  
**EASEMENTS ON THE CATAWBA RIVER USED FOR FLOW MITIGATION**



**FIGURE 40**  
**EASEMENTS ON THE CATAWBA RIVER USED FOR FLOW MITIGATION**



## Section 7

# Sustainability of the CRA

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The CRA represents a well-vetted robust operating license proposal, which has a positive overall impact on the resources and water quality of the Catawba and Wateree rivers. Duke has agreed to a flow and water quality implementation plan with an aggressive schedule designed to implement water quality enhancements as soon as feasible after the issuance of a New License and in some cases enhancements will be implemented prior to the issuance of a New License. The CRA includes other provisions that, while not direct water quality compliance provisions do provide additional long-term sustainability and stability along with an overall positive effect on the water quality and associated uses within the Catawba and Wateree rivers. In order to accomplish this long-term sustainability, there were numerous studies and assessments conducted by Duke and other stakeholders to provide insight and predictive capabilities for the Project. Following is a summary of these activities and the results that were achieved.

## 7.1 Additional Features of the CRA

### 7.1.1 Water Quality Management

- Buffers and Key Land Purchases: Duke deposited \$9.32 million into escrow accounts in January 2007 per CRA Section 14.5.3.3 to support the purchase of land in the Catawba-Wateree River Basin by the states of North Carolina and South Carolina for public recreation, gamelands and/or compatible permanent conservation including water quality protection. Both states responded to this opportunity with North Carolina using \$3.8 million towards the purchase of approximately 2,800 acres near Lake Rhodhiss known as the Johns River Gamelands Tract. This purchase preserved a significant portion of the Johns River Watershed. South Carolina used \$5.32 million towards the purchase of approximately 1,878 acres on the east side of Lake Wateree known as the McDowell Creek Tract. This tract contains 6 miles of protective easements on Lake Wateree and 2.5 bank miles of easements on tributary streams.

The South Carolina Department of Natural Resources purchased from Crescent Resources the 1,540-acre Heritage Tract in the Great Falls area featuring protective easements put in place by Duke. These conservation easements fulfill 2 miles of the Mitigation Plan protective easements called for in CRA Section 4.6.1.

- Shoreline Management Classifications and Guidelines: Duke has made significant modifications to its existing shoreline management classifications, lake use restrictions, and Shoreline Management Guidelines (SMG) in response to stakeholder interests and has implemented these improvements in advance of receiving a New License.
- Memorandum of Understanding: Duke has also offered to enter into a Memorandum of Understanding with municipalities, counties and states to improve data sharing, buffer enforcement, permitting reviews and scope of authority delineations.
- Upper Catawba Public Access, Open Space, and Trails Agreement: As required by the CRA, on April 30, 2008, NCDENR, Duke, and Crescent Resources signed an agreement that provides new trail easements through some of the conservation easements along the Catawba River and Warrior Fork in Burke County and the John River in Caldwell County. The key component of the Agreement provides NCDENR or its designee the opportunity to purchase almost 2,600 acres of lands predominately along the scenic Johns River in Burke County, with some parcels along the Johns and Wilson Creek in Caldwell County. Duke Ventures, a wholly owned subsidiary of Duke Energy, will acquire the properties from Crescent by June 30, 2008, and provide roughly 3 to 4 years for NCDENR to obtain funds from grants and other sources to acquire the lands. Land Purchase Options between The State of North Carolina and Duke Ventures will be finalized by March 1, 2009. Duke Ventures will reduce the purchase price by \$1,350 per acre, up to a total of \$3.5 million if all tracts are purchased. The acquisition of these 2,600 acres of riverine floodplains and uplands will help preserve a functional ecological corridor between the Johns River Gamelands at the confluence of the Johns and Catawba rivers upstream to Wilson Creek Gorge and the Appalachian Mountains.

- 50-Year License Provisions: CRA Parties agreed to the following additional resource enhancements in the event that the FERC issues a 50-year New License for the Project.
  - Duke shall establish permanent conservation easements on approximately 12.5 total bank miles (approximately 150 total acres) of selected tributaries to the Johns River.
  - Duke shall contribute an additional \$1.5 million for land conservation.
  - Duke shall establish permanent conservation easements on approximately 5.5 total bank miles (approximately 67 total acres) of selected portions of McDowell Creek, Cedar Creek, and Rocky Creek, and their tributaries, all of which are tributaries to Lake Wateree.
  - Duke shall establish permanent conservation easements, restrictive covenants, or a combination of the two, on the east shoreline of Lake Wateree from the downstream boundary of Cedar Creek Access Area to a point approximately 4.7 shoreline miles (as measured along the full pond contour) downstream. These conservation easements and/or restrictive covenants will provide land conservation support on a corridor extending 100 feet horizontally and upland from the full pond contour (total of approximately 57 acres).
  - Duke shall contribute an additional \$1.5 million for land conservation.

### 7.1.2 Resource Management

- Rare, Threatened, and Endangered Species: Duke will enter into formal species protection plans for the monitoring, management and protection of federal and state listed species including Rocky Shoals spider lily, Schweinitz's sunflower, dwarf-flowered heartleaf, bald eagle, shortnose sturgeon, and mussels. Duke will also make monetary contributions to the existing North Carolina and South Carolina Habitat Enhancement Programs.
- Cultural and Archeological Resources: A Historic Properties Management Plan will be implemented for future management of historic properties, powerhouse properties, and for future consultation with Native American tribes and state historic resource agencies. Important cultural and sacred properties are being leased to state resource agencies and to

the Catawba Indian Nation. The CRA also provides monetary support for initiatives at numerous historic sites.

### 7.1.3 Water Quantity Management

- Water Supply Study: This study documented the current water withdrawals and flow returns affecting the operation of the Project and developed long-term (50-year) projections of water withdrawals and flow returns based on established growth projections. The study also determined the safe yield (a risk parameter that is of particular interest to public water system operators) of the Project's reservoirs. This is the only comprehensive water supply inventory and assessment that exists for the Catawba-Wateree River Basin covering both North Carolina and South Carolina. Results of this study were used as key input to the basin-wide hydraulic modeling used to validate the long-term feasibility of the operating proposals in the CRA.
- Interbasin transfers: Stakeholders are extremely concerned about the current and projected future amount of water being withdrawn from the Catawba-Wateree River Basin to be transferred to adjacent basins and not returned to the Catawba-Wateree River Basin. Projected growth in inter-basin transfers was included in future water demand projections. However, neither the CRA nor this application comprehensively assess nor take a position on the approval of such future requests.
- Low Inflow Protocol/Critical habitat flows: A basin-wide LIP has been developed to balance water uses and to extend useable water storage as drought conditions emerge and intensify. The LIP establishes trigger points and procedures for aggressively reducing flow releases from the Project and other water demands during periods of low inflow. The LIP plays a significant role over the anticipated term of the New License in extending the available water supply when there is insufficient inflow to meet the normal demands and it is a major factor in achieving workable and sustainable lake levels and flow releases. In fact, the coordinated implementation of the LIP is expected to extend the point at which safe yields are reached for water supply intakes by a decade or more. Critical low lake

levels and critical low flow releases provide a safety net of protection for reservoir and riverine aquatic habitat, water withdrawer intake and discharge needs during low flow periods that has never existed before. The CRA also creates a Catawba-Wateree Drought Management Advisory Group to convene and coordinate actions in response to dry periods and droughts. The CRA also establishes a Water Management Group whereby Duke and Public Water System owners will pool their resources to tackle initiatives that will protect the water quantity and water quality in the Basin.

- **Recreation Flow Releases:** Dedicated recreation flows will be released at rates and on schedules that support paddling, wade fishing, boat fishing, and other activities such as duck hunting. These new scheduled flows will be provided in the four primary regulated river reaches as will canoeing and whitewater releases into the Great Falls Bypasses Reaches.

## **7.2 Assessments of Operational Scenarios**

Duke combined years of historical water quality monitoring records with supplemental water quality sampling conducted in 2004 to develop and calibrate hydrodynamic and water quality computer models of the tailrace and the downstream riverine systems (River Management System) and reservoirs (CE-QUAL-W2). These models have been utilized individually and collectively to assist stakeholder deliberations by predicting the downstream temperatures and DO concentrations (and transport of other water quality constituents) under a variety of Project operating conditions, which is beyond the capability of empirical data collection. The models have been used to quantify the extent of Project influence and non-point (nutrient) influence on downstream water quality, to evaluate feasible alternative operating or engineering scenarios, and to determine the water quality implications of certain aquatic in-stream flow proposals and low-inflow situations.

These models were used to evaluate the effect of the Project operations proposed in the CRA on a series of performance metrics for several reservoirs in the Catawba-Wateree River Basin (Lake James, Lake Hickory, Lake Norman, Lake Wylie, Lake Wateree, and Fishing Creek Reservoir).

The results of proposed future operation per the CRA were compared to those of current-day operations.

Water quality model results enable a relative comparison of whether proposed future CRA operations may be expected to have an enhancing, degrading, or neutral influence on various reservoir parameters. This assessment supplements the required tailwater water quality certification assessments by examining parameters that are not directly addressed by water quality standards and existing uses in the hydro station tailraces and riverine sections. The following metric comparisons were selected by the stakeholders comprising the Water Quality Resource Committee. Metrics are shown as “no significant impact” when the result of CRA operations and current day operations differ by less than 5 percent. Where NA appears, it indicates that stakeholders did not request that the parameter be evaluated at that location.

Overall these reservoir metrics improve slightly under the future operation of the Project proposed in the CRA. Most metrics (16) remain unchanged and exert no degrading influence on the chosen parameters. There are an equal number of significant enhancing influences (7) as there are degrading influences (7). However, the enhancing influences predominantly occur during normal flow years and by virtue of time would be expected to outweigh the degrading influences that all occur more infrequently during low flow years.

**TABLE 26**  
**METRICS USED TO EVALUATE WATER QUALITY EFFECTS OF THE**  
**CATAWBA-WATEREE COMPREHENSIVE RELICENSING AGREEMENT**

<b>Metric</b>	<b>James</b>	<b>Hickory</b>	<b>Norman</b>	<b>Wylie</b>	<b>Fishing Creek</b>	<b>Wateree</b>
<b>Percentage of volume-days from May through October with dissolved oxygen &gt; 5.0 mg/l</b>	No significant impact	No significant impact	No significant impact	No significant impact	NA	No significant impact
<b>Percentage of volume-days from May through October with dissolved oxygen &lt; 1.0 mg/l</b>	During normal flow years, the percentage falls (enhances) from 2.3% under current day operations to 2.0% under CRA operations.	No significant impact during normal flow years. During low-flow years this percentage rises (degrades) from 6.1% under current day operations to 9.7% under CRA operations.	During normal flow years this percentage enhances from 2.3% under normal operations to 2.1% under CRA operations. During low flow years, this percentage enhances from 1.8% under current day operations to 1.6% under CRA operations.	No significant impact during normal flow years. During low flow years, this percentage degrades from 5.9% under current day operations to 6.7% under CRA operations.	NA	During normal flow years this percentage enhances from 1.6% under normal operations to 1.1% under CRA operations. During low flow years, this percentage enhances from 3.1% under current day operations to 3.2% under CRA operations.
<b>Walleye Preferred Habitat (Temp &lt;24°C and DO &gt;4.0 mg/l)</b>	No significant impact	NA	NA	NA	NA	NA
<b>Walleye Tolerable Habitat (Temp &lt;29°C and DO &gt;2.0 mg/l)</b>	No significant impact	NA	NA	NA	NA	NA
<b>Striped Bass Preferred</b>	NA	No significant impact during	No significant impact	No significant impact during normal flow	NA	No significant impact

<b>Metric</b>	<b>James</b>	<b>Hickory</b>	<b>Norman</b>	<b>Wylie</b>	<b>Fishing Creek</b>	<b>Wateree</b>
<b>Habitat (Temp &lt;20°C and DO &gt;4.0 mg/l)</b>		normal flow years. During low flow years, this percentage degrades from 16.4% under current day operations to 15% under CRA operations.		years. During low flow years, this percentage degrades from 6.2% under current day operations to 5.5% under CRA operations.		
<b>Striped Bass Tolerable Habitat (Temp &lt;27°C and DO &gt;2.0 mg/l)</b>	NA	No significant impact during normal flow years. During low flow years, this percentage degrades from 68.3% under current day operation to 59% under CRA operation.	No significant impact	No significant impact	NA	No significant impact
<b>Maximum Chlorophyll a Concentration (mg/l)</b>	NA	No significant change during normal flow years. During low flow years, this concentration improves from 41.9 mg/l under current day operations to 36.5 mg/l under CRA operations.	NA	No significant change under normal flow conditions. Under low flow conditions, this concentration degrades from 51.7 mg/l to 58.7 mg/l although mean surface concentrations improve slightly from 22 mg/l under current day operations to 21.6 mg/l under CRA operations.	No significant impact.	No significant impact.
<b>Mean Surface Chlorophyll a Concentration April - August</b>	NA	No significant change.	NA	See above.	During low flow years, this concentration degrades from 20.5 mg/l under current day	During normal flow years, this concentration enhances from 11.5

<b>Metric (mg/l)</b>	<b>James</b>	<b>Hickory</b>	<b>Norman</b>	<b>Wylie</b>	<b>Fishing Creek</b>	<b>Wateree</b>
					operations to 27.8 mg/l under CRA operations. However, during normal flow years, this concentration enhances significantly from 12.1 mg/l under current day operations to 10.7 mg/l under CRA operations.	mg/l under current day operations to 10.2 mg/l under CRA operations.

## Section 8

# **The Santee River Basin Accord for Diadromous Fish Protection, Restoration, and Enhancement**

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The Santee River Basin Accord (“Accord”) is a collaborative approach among utilities with licensed hydroelectric projects, and federal and state resource agencies to address diadromous fish protection, restoration, and enhancement in the Santee River Basin (“Basin”). This Accord supports the *Santee-Cooper Basin Diadromous Fish Passage Restoration Plan* (2001) which was developed by the South Carolina Department of Natural Resources (“SCDNR”), the National Oceanic and Atmospheric Administration’s National Marine Fisheries Service (“NMFS”), and the United States Fish and Wildlife Service (“USFWS”), and was accepted as a Comprehensive Plan by the Federal Energy Regulatory Commission (“FERC”) as noted in the FERC’s letter to the USFWS dated October 3, 2001.

Accord participants and hydroelectric projects that are the subject of this Accord include South Carolina Electric & Gas Company (“SCE&G”), licensee of the Saluda Hydroelectric Project No. 516, the Parr Hydroelectric Project No. 1894, and the Neal Shoals Hydroelectric Project No. 2315, and Duke Energy Carolinas, LLC (“Duke”), licensee of the Catawba-Wateree Hydroelectric Project No. 2232, the Ninety-Nine Islands Hydroelectric Project No. 2331, and the Gaston Shoals Hydroelectric Project No. 2332 (SCE&G and Duke referred to herein singularly as “Utility” and together as “Utilities”) and their successors; and the SCDNR, the North Carolina Wildlife Resources Commission (“NCWRC”), and the USFWS (referred to herein singularly as “Agency” and together as “Agencies”) and their successors. Singularly, any Utility or Agency that signs this Accord may be referred to herein as “Party”. Collectively, the Utilities and Agencies that sign this Accord constitute the Cooperative Accord Partnership (“CAP” or “Parties”). The NMFS and the South Carolina Department of Health and Environmental Control (“SCDHEC”) were also involved in the development of this Accord, but neither are currently signatories to the Accord.

This Accord constitutes an agreement among the CAP members for the protection, restoration, and enhancement of diadromous fish in the Basin through implementation of a 10-year Action Plan (“Plan”) that was initially developed by the USFWS (*Cooperative Accord 10-Year Action Plan For The Restoration and Enhancement of Diadromous Fish In The Santee Basin*—original

draft dated January 24, 2007), and that includes no-sooner-than dates and biological triggers for fish passage. Tasks and cost estimates for each activity in the Plan are presented in the Accord along with no-sooner-than dates, biological triggers, and other agreed-upon actions. The agreements, activities, and biological studies identified in the Accord will be used to support the development of fish passage prescriptions that will protect, restore, and enhance diadromous fish in the Basin for some of the above-referenced Projects. The CAP members have worked to create this Accord to meet the interests of CAP members while still allowing all Agencies and Jurisdictional Bodies to meet their respective statutory obligations for diadromous fish under §7 of the Endangered Species Act (“ESA”) and under §4(e), §10(a), §10(j), and §18 of the Federal Power Act (“FPA”), and under §401 of the Clean Water Act (“CWA”), for the above-referenced Projects. The CAP has agreed to implement phased, deliberate, and effective activities that will initiate diadromous fish population enhancements in the near-term while collecting data and monitoring diadromous fisheries over a longer period for optimizing further restoration efforts.

By signing the Accord, the NCWRC, the SCDNR, and the USFWS all consider the continuous minimum instream flows and the bypass flows proposed in the CRA to be adequate for the protection of Project resources. The Accord includes recourse provisions should (a) any requirement, condition, prescription, or recommendation imposed by a Jurisdictional Body pursuant to §§4(e), 10(a), 10(j), or 18 of the FPA, §7 of the ESA, or §401 of the CWA for operation of the Project materially vary any obligation concerning the restoration of diadromous fish, reservoir elevation limitations, required flow releases, and low inflow protocols or HIPs from those set forth in the CRA, as amended on December 29, 2006, or in an Existing Project License; or (b) should any requirement, condition, prescription, or recommendation imposed by a Jurisdictional Body pursuant to §§4(e), 10(a), 10(j), or 18 of the FPA, §7 of the ESA, or §401 of the CWA that materially vary any obligation from those set forth in the Accord. The Accord also contains recourse provisions in the event of a failure of a Party to comply with the terms of the Accord in a significant and non-trivial manner and includes, but is not limited to: (a) a requirement, condition, prescription, or recommendation for a Project that is imposed by an Agency pursuant to §§4(e), 10(a), 10(j), or 18 of the FPA, or §7 of the ESA that materially varies any obligation set forth in the Accord; or (b) any CAP member’s requesting, promoting, or supporting an Inconsistent Act or other requirements that materially varies any obligation set forth in the Accord.

## Section 9

# Summary and Conclusions

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According to state water quality certification regulations, a water quality certification should be issued for any project discharging to surface waters that meets established state criteria. The following criteria are intended to reflect the considerations and requirements that would have to be addressed to the satisfaction of both North Carolina and South Carolina water quality agencies. The subject of this certification and therefore of this evaluation is the continued operation of the Project under a New License issued by the Federal Energy Regulatory Commission that is consistent with the applicable sections (refer to Section 3.5 of this SIP) of the CRA for the Project. This section addresses this application's compliance with each criterion.

### **1. The project is water dependent and has no feasible/practical alternative.**

The continued operation of the Project has no practical alternative. Fourteen counties and more than 30 municipalities depend now and in the future on the following critical benefits provided by the Project that cannot be practically replaced:

- Energy: In addition to currently providing the energy to power 116,000 homes (on an average yearly basis) and water to support over 8,100 megawatts (MW) of fossil and nuclear-fueled power plants (44 percent of Duke's North Carolina and South Carolina generating fleet), the Project is a critical component in meeting future electric supply needs. Duke's system demand for electricity in North Carolina and South Carolina is expected to more than double over the next 50 years and a substantial portion of that new generation capacity is expected to rely on the Project.
- Drinking Water: The Project provides a reliable drinking water supply for over 1.3 million people. Future public water supply needs are projected to increase over 200 percent in the next 50 years.
- Jobs: The Project also provides a reliable water supply that is vital to the operations of several large industrial facilities, a key component to the economic vitality of the region.

- 2. The project will minimize adverse impacts to the surface waters based on consideration of existing topography, vegetation, fish and wildlife resources, and hydrological conditions.**

As further elaborated upon in Section 5 of this SIP and in Items 3 through 6 below, there are expected to be no adverse impacts to existing uses resulting from continued operation of the Project under a New License consistent with applicable sections of the CRA.

- 3. The project does not result in the degradation of groundwater or surface waters.**

Where surface water quality exceeds levels necessary to support propagation of fish, wildlife, and recreation in and on the water, that quality is not allowed to be degraded below the level needed to maintain the existing uses that those waters currently support and the anticipated uses of those waters.

No losses of existing uses are anticipated when operating the Project under a New License consistent with applicable sections of the CRA. At almost all locations, water quality enhancements, higher continuous flows, drought management (LIP), SMP enhancements, and the incorporation of future water supply needs all serve to enhance and protect existing uses. Since all existing uses are enhanced except for three locations (please refer to Item 6 below) where existing uses are unchanged, there is no expected degradation in existing uses.

Please refer to Item 5 that follows. The measures that are proposed to be implemented by the applicant will enhance water quality and meet downstream water quality standards in the future. No degradation of existing water quality is expected to occur.

**4. The project does not result in cumulative impacts, based upon past or reasonably anticipated future impacts, which cause or will cause a violation of downstream water quality standards.**

The objective of a cumulative impact assessment is to determine whether the impacts resulting from the continued operation of the Project under a New License from the Federal Energy Regulatory Commission and in accordance with the applicable sections of the CRA, when added to other past, present or reasonably anticipated future impacts, cause or will cause a violation of downstream water quality standards.

The nature of the new equipment implementations and operational modifications presented in the CRA and in Table 4 of the application form in order to deliver the agreed-upon higher minimum continuous flows and to meet water quality standards for DO all serve to enhance (raise) DO concentrations. The proposed future operation of the Project is not projected to diminish water quality, thus, there is no scenario in which reasonably anticipated future water quality impacts could be further diminished via combining with the water quality enhancements resulting from operating the Project per applicable sections of the CRA.

Duke and other Catawba-Wateree stakeholders have incorporated the following reasonably anticipated future impacts into their studies, modeling and deliberations to insure that these future events have been considered and that the CRA is resilient in the event of these occurrences:

- Future (50-year) public water needs estimate
- Future new power generation water needs estimate
- Potential future inter-basin transfer water requests
- Potential future droughts

**5. The project provides for protection of downstream water quality standards with on-site stormwater control measures.**

Other than constructing a new powerhouse at the Bridgewater Development, this application does not contemplate land-disturbing activities or construction (dredging or filling) work within the waters of the Project. The implementation of water quality related equipment modifications will begin upon receiving certifications from North Carolina and South Carolina and a New License from the FERC. Therefore, stormwater control measures are not applicable for this application. Necessary construction-related permits and certifications for the new Bridgewater Powerhouse construction project as well as any other activities requiring dredge or fill permits to implement other provisions of the CRA will be applied for separately.

Table 4 of the 401 Water Quality Certification Application summarizes the measures that are proposed to be implemented by the applicant to enhance water quality and meet downstream water quality standards in the future. The projected result of implementing these modifications and assessment of compliance with state standards is presented in Section 5 of this SIP for each hydro station.

Sections 4 and 5 of this SIP provide reasonable assurance that all stations are projected to meet state water quality standards for DO.

**6. The project provides for replacement of existing uses through mitigation.**

No losses of existing uses are anticipated when operating the Project under a New License consistent with applicable sections of the CRA.

At almost all locations, water quality enhancements, higher continuous flows, drought management (LIP), shoreline management plan enhancements, and the incorporation of future water supply needs all serve to enhance and protect all existing uses.

There are only three locations in the Project where no operational changes are proposed and for which existing uses will remain unaltered.

- Paddy Creek Bypassed Reach: This creek (0.7 mile long) flows from the Paddy Creek Dam at Lake James into the Catawba River Bypassed Reach. Stakeholders toured the Catawba River and Paddy Creek bypassed reaches and observed that the Paddy Creek channel has been severely impacted by high tropical storm spill flows to the point that the potential for significant aquatic habitat restoration is low. The Aquatics Resource Committee agreed to a) not invest in the high implementation cost required to deliver flow into this creek for a speculative gain, b) instead focus on maximizing habitat in the higher priority Catawba River Bypassed Reach and the river below the Bridgewater Powerhouse, and c) fully mitigate for the aquatic habitat not realized in Paddy Creek.
- Mountain Island Bypassed Reach: This bypass (0.3 mile long) is unique in that a large colony of a federally listed endangered species, the Schweinitz's sunflower, has become established in the bypass channel. The current habitat in this location supports this species. Due to the short length of this bypass and in order to not alter the habitat supporting this rare sunflower species, stakeholders agreed to not introduce higher flow releases and to fully mitigate for the aquatic habitat not realized in the Mountain Island Bypassed Reach.
- Wateree Spillway Channel: Flow through the Wateree Powerhouse is released into an excavated channel that runs roughly parallel to the original Wateree River channel at the base of Wateree Dam. The original channel (0.4 mile long) receives intermittent inundation from powerhouse flow releases and spills over the Wateree Dam, but its flow regime is significantly altered. Releasing continuous flows (especially high spring spawning flows) into this channel rather than through the generators is a significant hydroelectric energy generation (an existing use) impact to Duke. Alternatively, providing flows into the channel in addition to powerhouse releases can at times strain the water storage in the Catawba-Wateree River Basin. For these reasons plus the fact that this channel carries no unique Critical Habitat designations for shortnose sturgeon or any other rare, threatened, or

endangered species, stakeholders agreed to not introduce higher flow releases and to fully mitigate for the aquatic habitat not realized in the Wateree Spillway Channel.

There are three locations in the Project where flow and water quality enhancements are proposed to be made and existing uses are enhanced, but the level of enhancement does not fully meet the goal of state and federal resource agencies.

At Oxford, significant expense and a high flow release would be required in order to completely inundate the wide, braided tailrace channel. At Lookout Shoals, the length of the riverine section below the hydro station varies significantly. If Lake Norman is near its high elevation, the riverine section is very short. The maximum tailrace length does not exist but a few months out of the year. In the Great Falls Long Bypassed Reach, a point of diminishing return was reached such that beyond the flows currently proposed, very little additional wetted perimeter was gained under significantly larger flow releases. Also, flows in the Great Falls Long Bypassed Reach reduce electric generation (an existing use) at the Dearborn Powerhouse and higher flows would exacerbate this loss even more. Stakeholders agreed to not introduce higher flow releases and to mitigate for the portion of the aquatic habitat goal not realized at these locations.

At “lake-to-lake” tailraces (Rhodhiss, Cowans Ford, Mountain Island, Fishing Creek, Great Falls-Dearborn, and Rocky Creek-Cedar Creek), the downstream reservoir backs up into the powerhouse tailrace. At these lake-to-lake locations, the tailwater character will remain lacustrine in nature and would not reasonably be expected to change in nature under minimum continuous flows that are more appropriately intended to enhance riverine aquatic habitat. However, the reservoir headwater in the vicinity of the hydro tailrace may benefit from DO enhancements.

All existing uses are enhanced save for three locations where existing uses are unchanged (unenhanced) and three locations where enhancements will be achieved but do not reach the level of enhancement desired by resource agencies. In order to address these locations where resource agency aquatic habitat goals may not be fully met, Duke has consulted with resource agencies and per the CRA has agreed to provide mitigation. This mitigation complies with North

Carolina Department of Environment and Natural Resources Division of Water Quality guidance document entitled *Stream Mitigation for FERC-related 401 Certifications, Internal DWQ Guidance, NC Division of Water Quality*. These guidelines are also consistent with the USACOE Stream Mitigation Guidelines. This guidance document was used for both the North Carolina and South Carolina mitigation packages (refer to CRA Sections 4.5 and 4.6). Details regarding the application of this guidance document to the Project and the resulting mitigation package requirements are found in Section 6 of this SIP.

As an additional enhancement not explicitly included in the mitigation packages, the CRA includes that Duke will install new minimum flow aerating turbines at the Wylie Development and Wateree Development. These are multi-million dollar investments and will be made significantly before the targeted turbines are due to be replaced. These investments will provide the steady flow releases necessary to fully enhance an additional 5 miles (Wylie) to 7 miles (Wateree) of stream habitat immediately below each station. This is habitat that would not otherwise be fully enhanced under pulsing operations utilizing the current turbines at these stations.

## Section 10

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## **APPENDICES**

**APPENDIX A**  
**QUALITY ASSURANCE PROJECT PLAN**

**CATAWBA-WATEREE TAILWATER DISSOLVED OXYGEN  
MONITORING**

**FERC PROJECT NO. 2232**

**QUALITY ASSURANCE PROJECT PLAN (QAPP)**

**DRAFT**

Effective Date:  
Revision No.



**QUALITY ASSURANCE PROJECT PLAN**

**CATAWBA-WATEREE PROJECT, FERC No. 2232**

**Effective Date:**

**DOCUMENT APPROVAL PAGE**

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**Tyrus Ziegler**  
**Field Monitoring Manager, Devine Tarbell and Associates**

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**GROUP A - PROJECT MANAGEMENT****A1.0 Distribution List**

This Quality Assurance Project Plan (QAPP) will be distributed to the following agencies and entities with an interest or role in water quality monitoring conducted by Duke Energy Carolinas, LLC (Duke or Licensee) for the Catawba-Wateree Hydroelectric Project (FERC No. 2232).

**Table 1: Contacts Receiving Duke Energy Catawba-Wateree QAPP**

Dianne Reid	North Carolina Division of Water Quality
John Dorney	North Carolina Division of Water Quality
Heather Preston	South Carolina Department of Health and Environmental Control
Chuck Hightower	South Carolina Department of Health and Environmental Control
Rusty Wenerick	South Carolina Department of Health and Environmental Control
Ben West	U.S Environmental Protection Agency
Scott Holland	Duke Energy Corporation
Mark Oakley	Duke Energy Corporation
George Galleher	Duke Energy Corporation
Tyrus Ziegler	Devine Tarbell and Associates
Steve Johnson	Devine Tarbell and Associates
Jon Knight	Devine Tarbell and Associates

## A2.0 Project Organization

The Duke Energy Carolinas, LLC (Duke) Hydro Operations Compliance Engineer will serve as the Project Manager (PM) and is responsible for overseeing all aspects of the continuous dissolved oxygen (DO) monitoring program in the Catawba-Wateree Project tailwaters, including oversight of the subcontractor collecting the data in accordance with the Water Quality Monitoring Plan (WQMP) (Appendix A-QAPP) for the Project and this QAPP. The Duke PM is responsible for reporting data to the North Carolina Division of Water Quality (NCDWQ) and the South Carolina Department of Health and Environmental Control (SCDHEC) as described in Section A4.

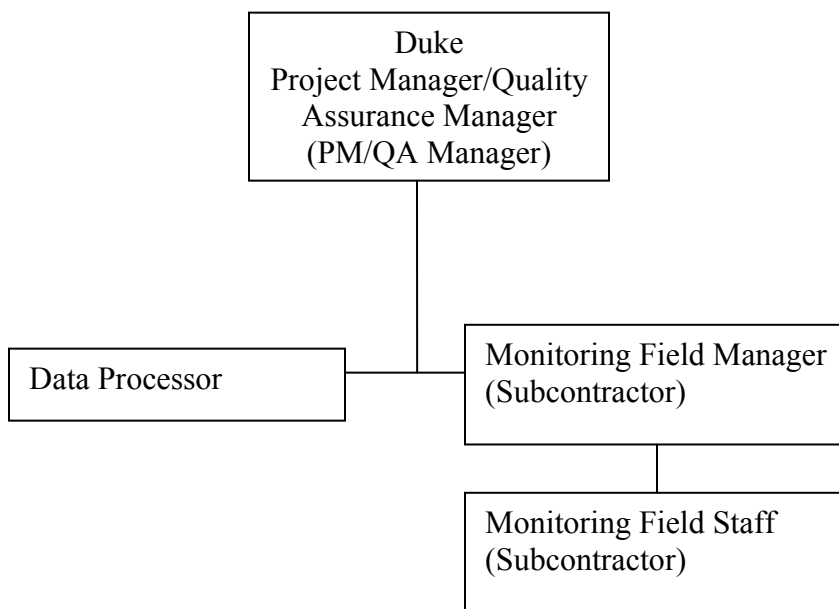
The Duke Hydro Operations Compliance Engineer also acts as the Project Quality Assurance (QA) Manager and is responsible for maintaining the QAPP and Quality Assurance/Quality Control (QA/QC) files. The Duke PM/QA Manager does not supervise or manage the personnel responsible for collecting the data. The Duke PM/QA Manager is responsible for the final review of documentation for the QA/QC file and that data collection is consistent with this QAPP.

The Monitoring Field Manager (subcontractor) is responsible for the review of data and supporting documentation prior to submittal to the Duke PM/QA Manager. The Monitoring Field Manager is also responsible for directly overseeing the Monitoring Field Staff (subcontractor) and the day-to-day coordination of field collection and equipment maintenance in accordance with this QAPP, the Water Quality Monitoring Plan (WQMP) and all associated Standard Operating Procedures (SOPs). The Monitoring Field Manager is responsible for reporting any equipment/calibration issues to the Data Processor and for making decisions related to corrective action related to equipment/calibration issues encountered by Monitoring Field Staff. The Monitoring Field Manager also makes recommendations for flagging data that may be affected due to known equipment/calibration issues.

The Monitoring Field Staff (subcontractor) are responsible for maintaining functioning instruments, performing calibration procedures as required, collecting and downloading data, and maintenance of field log books in accordance with this QAPP, the WQMP and all associated SOPs. Field Staff are responsible for reporting any equipment/calibration issues to the Monitoring Field Manager.

The Data Processor is responsible for the data that are processed into an annual database and electronic spreadsheets. The Data Processor is responsible for software support and maintaining the interface between the instruments and the receiving station, for reviewing selected portions of the individual data files and for maintaining records of changes or flagging of data in the database.

The organizational relationship of these functions is presented in Figure 1.

**Figure 1: Program Organization Chart**

### **A3.0 Project Definition/Background**

#### **A3.1 Background**

Duke Energy Carolinas, LLC (Duke) is applying for a new operating license from the Federal Energy Regulatory Commission (FERC) for the Catawba-Wateree Hydro Project (all eleven impoundments and thirteen powerhouses are included in the Catawba-Wateree License, see Figure 2). Along with development of its license application, Duke has developed a Comprehensive Relicensing Agreement (CRA) along with stakeholders to address many Project-related issues.

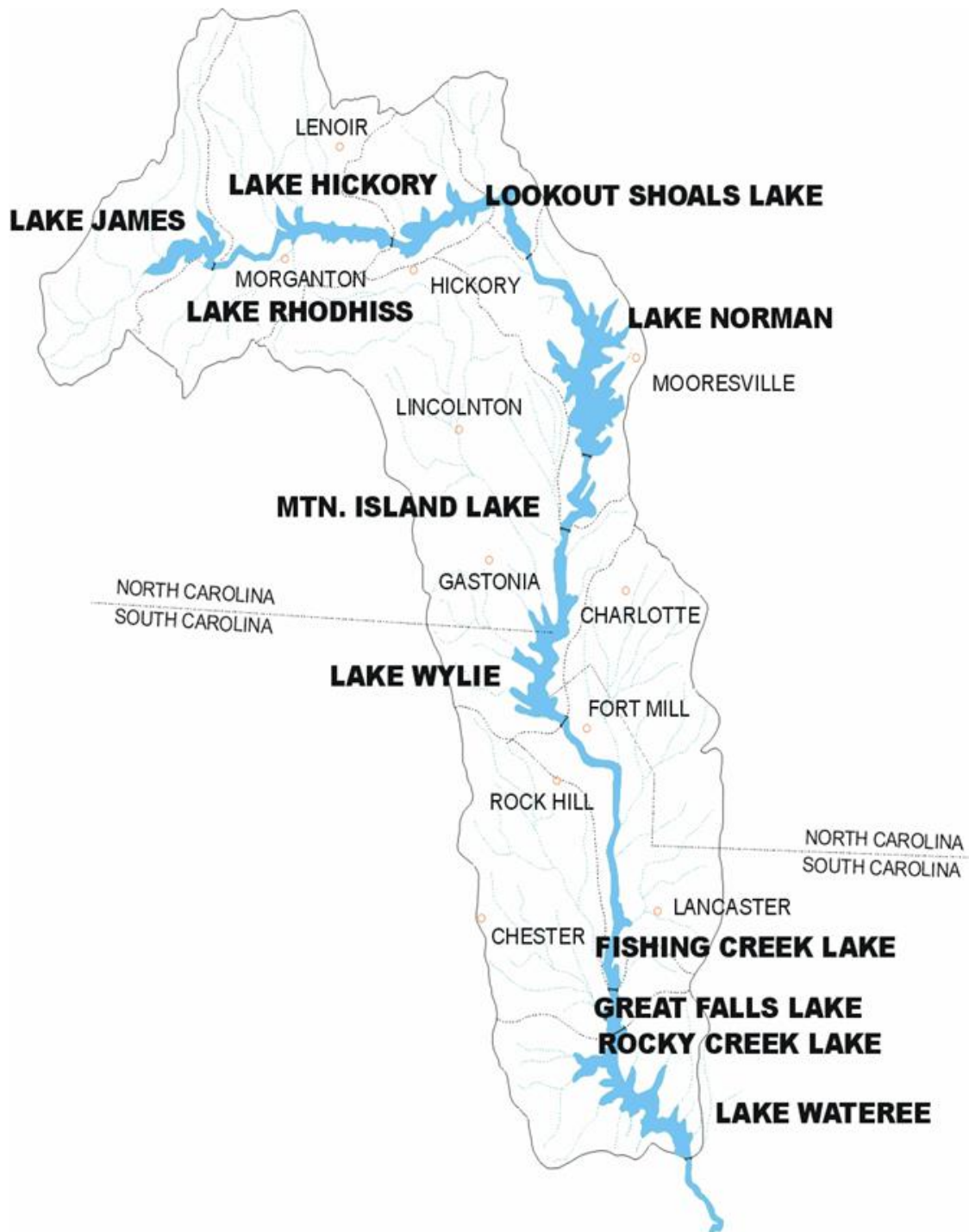
One of the proposed license articles in the Application for New License stipulates a Flow and Water Quality Implementation Plan (FWQIP) to enhance the aquatic resources by improving flow conditions for fish and wildlife and by meeting state dissolved oxygen standards. Even though Duke has previously modified many of the turbines to increase the capacity to aerate the downstream releases, additional plant modifications are necessary to enhance the aeration capacity and/or meet the minimum flow requirements stipulated in the CRA. The FWQIP describes the additional physical modifications, the schedule for completion of the modifications, and any interim measures prior to the physical installation of the equipment. This document is available in Table 4 of the 401 Water Quality Certification Application.

An additional proposed article for the new license is the Water Quality Monitoring Plan (WQMP). This proposed article describes a monitoring program at each hydroelectric station. The WQMP discusses two major activities for water quality monitoring. The first activity is the measurement and reporting of dissolved oxygen concentrations (DO) for the duration of the

license (this activity is the focus of this QAPP). The second activity is the measurement of temperature and flow downstream of the Bridgewater project to verify the computer modeling used to establish the flow release patterns into the bypassed reach and the downstream river channel (discussed in Appendix B-QAPP).

The purpose of this QAPP is to provide a quality assurance/quality control program for the proposed DO monitoring described in the WQMP. This QAPP documents the data collection procedures and database management activities to ensure that valid data are used by Duke, NCDWQ, and SCDHEC to evaluate compliance to state dissolved oxygen (DO) standards. This QAPP was developed in accordance with the USEPA guidance document “Guidance for Quality Assurance Project Plans, EPA QA/G-5” dated December 2002.

Figure 2: Catawba-Wateree Project Location Map



### A3.2 Problem Statement

The goal of the Catawba-Wateree QAPP/WQMP is to provide quality, real-time dissolved oxygen (DO) and temperature data for the project releases. This real-time data will be used by operators to adjust hydro operations to maintain compliance with state DO standards and the requirements of the FERC license. In addition, this data will be used for reporting compliance, and/or non-compliance events to appropriate agencies, as well as conducting on-going evaluations regarding equipment performance and operational guidelines.

### A4.0 Project Task Description

Duke's Monitoring Field Staff will collect DO and water temperature data in accordance with the WQMP. Table 2 summarizes the tasks anticipated to occur under the WQMP and this QAPP. The QAPP will become effective upon final 401 Water Quality Certification by NCDWQ and SCDHEC.

The following is a general schedule for the monitoring activities discussed here:

**Table 2: Water Quality Monitoring Schedule**

Task	Timeframe	Notes
Water Quality Monitor installation	12 months after FERC approves the FWQIP (subject to approval in NC and SC 401 Water Quality Certification) per CRA, Appendix M	At several locations, the installation of water quality monitors will precede the installation of the equipment modifications necessary to achieve compliance. In these cases, the monitors will assist Duke in the implementation of interim measures per the FWQIP. However, these monitor results are not suitable for compliance assessments until the necessary equipment modifications have been implemented (refer to CRA Section 13.2)
DO Monitoring	April 1 – November 30	Each year for the term of the license, per WQMP/FWQIP
Temperature Monitoring	April 1- November 30	Each year for the term of the license, per WQMP/FWQIP
Annual Report Submitted	June 30	The annual report will reflect previous year's data; annual reports submitted for the term of the license

### A5.0 Quality Objectives and Criteria

The objectives of data measurement, collection, and retention are to provide real-time, continuous information to hydro operators to ensure compliance with applicable State Water Quality Standards and FERC license requirements and to provide historical information to operators for continuous improvement of procedures and operations. The following considerations are necessary that the DO sensor be:

- representative of water quality conditions during all Project operations;
- secure (minimize probability of vandalism);
- accessible for maintenance at all flows; and;
- at a distance downstream to achieve a small time-lag between changes in Project operations and monitor response

- e. maintained to enable a performance within the manufacture's stated accuracy

Calibrated and well maintained water quality sensors usually provide more accurate readings than those given by the manufacturer. Routine maintenance and calibration of oxygen sensors is critical since the DO probes are prone to fouling (biological and chemical), which typically results in readings of lower DO concentrations than actually exist. The maintenance and calibration procedures (see Section B7.0) are designed to keep the measurements well within the limits specified by the manufacturer.

#### **A6.0 Special Training/Certification**

All personnel responsible for field monitoring must be familiar with this QAPP and the attached Standard Operating Procedures (SOP).

The Monitoring Field Manager will review, and, if necessary, train the Monitoring Field Staff prior to each monitoring season. The training will consist of:

- Current field procedures and SOPs,
- Changes, if any, from previous years, and
- Continuous improvement items identified from past data analysis.

The Monitoring Field Manager will observe the field techniques of the Field Staff at periodic intervals throughout the monitoring season. Any issues with technique will be corrected at that time and documented in the appropriate field log book.

All personnel responsible for field monitoring must complete safety training as required by regulating agencies and Duke. Completion of this training will be required on an annual basis will be documented. All training records will be maintained by the Duke PM/QA Manager.

#### **A7.0 Documents and Records**

All personnel with a role in implementing the WQMP will receive the most recently approved QAPP and associated documents. These documents will be updated as necessary by the Duke PM/QA Manager and distributed to all parties listed in Section A1. Any revisions to the QAPP will be noted on the title page with the revision number and effective date. Only the Duke PM/QA Manager will have access to making revisions to the electronic copy of the QAPP, Duke's PM/QA manager is also responsible for obtaining appropriate revision approvals by NCDWQ and SCDHEC and retention of all revisions to the QAPP.

Revisions to the QAPP may include but not limited to:

- Procedural changes due to continuous improvement activities identified throughout the course of monitoring,
- Procedural changes due to technological changes and/or improvements,
- FERC License revisions or requirements, and
- Water quality agency revisions or requirements.

As specified in the SOP's, during the monitoring season, the Monitoring Field Staff will:

- Maintain records of calibration,
- Maintain records of maintenance,
- Maintain records of instrument failure,
- Maintain records of corrective action, and
- Maintain any other field notes/information in field log books.

The field staff will transfer these records electronically to the Monitoring Field Manager on a periodic basis as specified in the SOP's.

The Monitoring Field Manager will summarize all field staff records and monitoring data on a periodic basis throughout the monitoring season. These electronic summaries will be reviewed by the Field Manager and transferred to the Duke PM/QA Manager periodically throughout the monitoring season. All original raw data records (paper and electronic) collected by the field staff during the monitoring season will be transferred to the Duke PM/QA Manager at the end of the monitoring season. The Duke PM/QA Manager will maintain copies of these records in the QA/QC files for this monitoring project for the term of the Catawba-Wateree Project FERC License.

The Monitoring Field Manager will maintain scans of all forms and all data files in electronic format for five years. Access to these files is controlled by the Monitoring Field Manager.

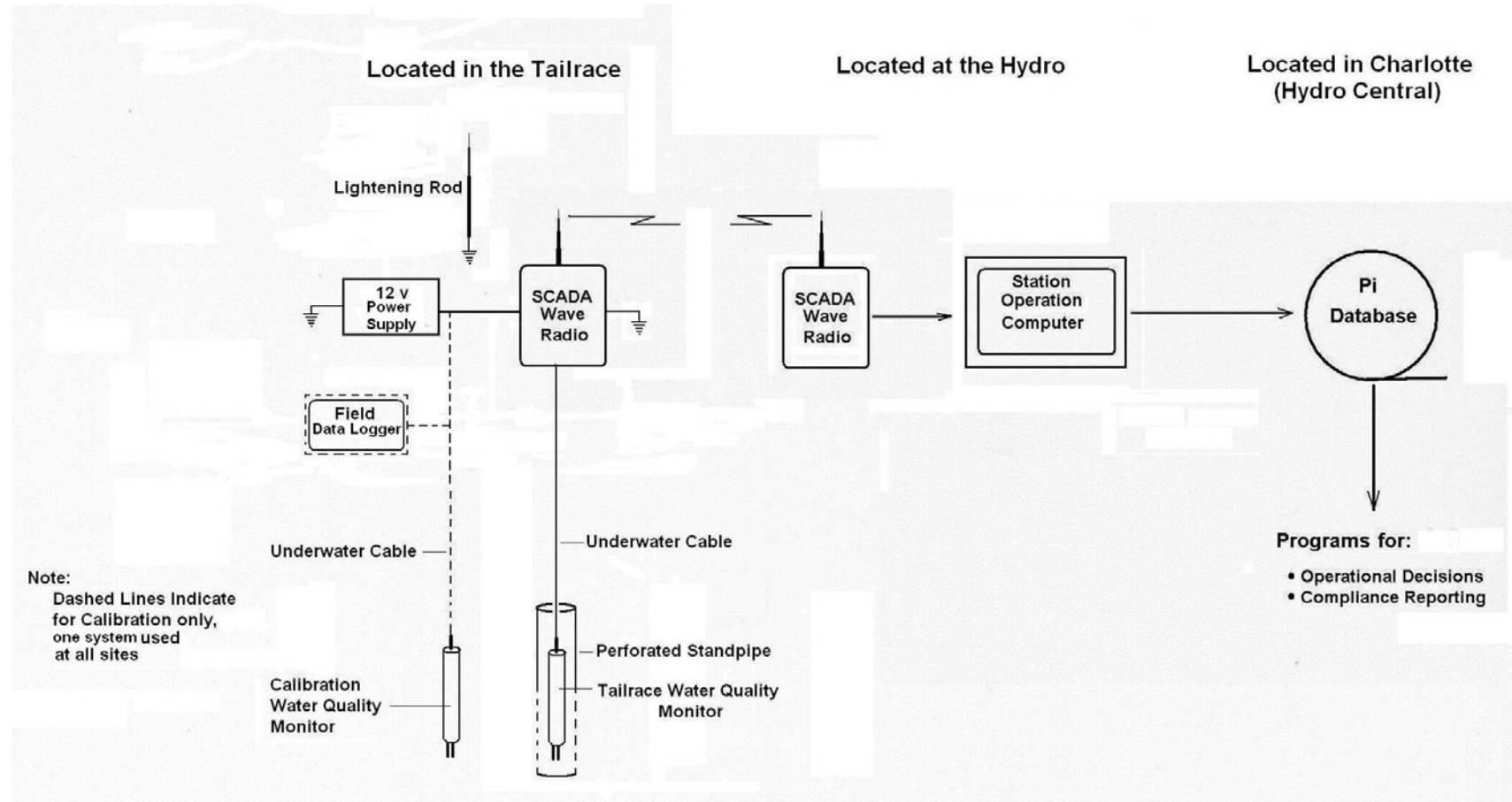
All non-compliance communications and annual compliance reports submitted to NCDWQ and SCDHEC (see Section A4) will also be maintained in hard copy and electronic format by the Duke PM/QA Manager for the term of the new License.

Details of electronic data management are further described in Section B10 of this QAPP.

## **GROUP B - DATA GENERATION AND ACQUISITION**

### **B1.0 Study Design**

The purpose of monitoring temperature and dissolved oxygen in the water released from the hydro is to ensure that the DO concentration in that water meets or exceeds applicable state WQ standards. The study design was based upon the work by Wagner et al. (2000) and modified to meet specific monitoring objectives described in the License Application. The basic components of the monitoring system are (1) sensors that measure the temperature and dissolved oxygen, (2) a means of getting the sensor data to an appropriate database, and (3) a database capable of meeting the operational and reporting requirements.

**Figure 3: System Overview – this configuration will be provided at each hydro facility**

**Component Description****Tailwater Water Quality Monitor**

The DO sensor utilizes the most current, practical technology to measure dissolved oxygen. Currently, a luminescence quenching sensor (LDO) to measure dissolved oxygen is planned for tailrace monitoring. This type of sensor is the latest technology which drastically reduces the frequency of maintenance and calibration of the DO electrode (contrasted to the traditional Clark Cell). The monitor also has a temperature sensor. The sensor has a Modbus communication protocol for direct connection to the SCADA wave radio (no additional programming is necessary).

**Perforated Standpipe**

This 6-inch diameter, PVC pipe is attached to a structure (concrete wall, bridge piling, etc.) to provide a permanent housing for the sensor. This pipe, perforated on the lower end allows for free exchange of water and protects the sensor and cables from physical damage, vandalism, and lightening.

**Tailwater Sensor Cables**

Standard, off-the-shelf, cables are supplied by the sensor vendor. These cables allow power to be supplied to the instrument as well as data transmittal to the SCADA wave radio. Each cable end has a specified fitting for the designated mated end. These cables were chosen (in lieu of custom fabrication of wiring components) to allow rapid troubleshooting and replacement (if necessary).

**Power Supply, 12 v**

Supplies power to SCADA wave radio and sensors

**SCADA Wave Radio**

This is the standard Duke radio link to send and receive data. The SCADA radio transfers data from remote sensors to the Fix32 system computer. Line of sight clearance is required between radio links.

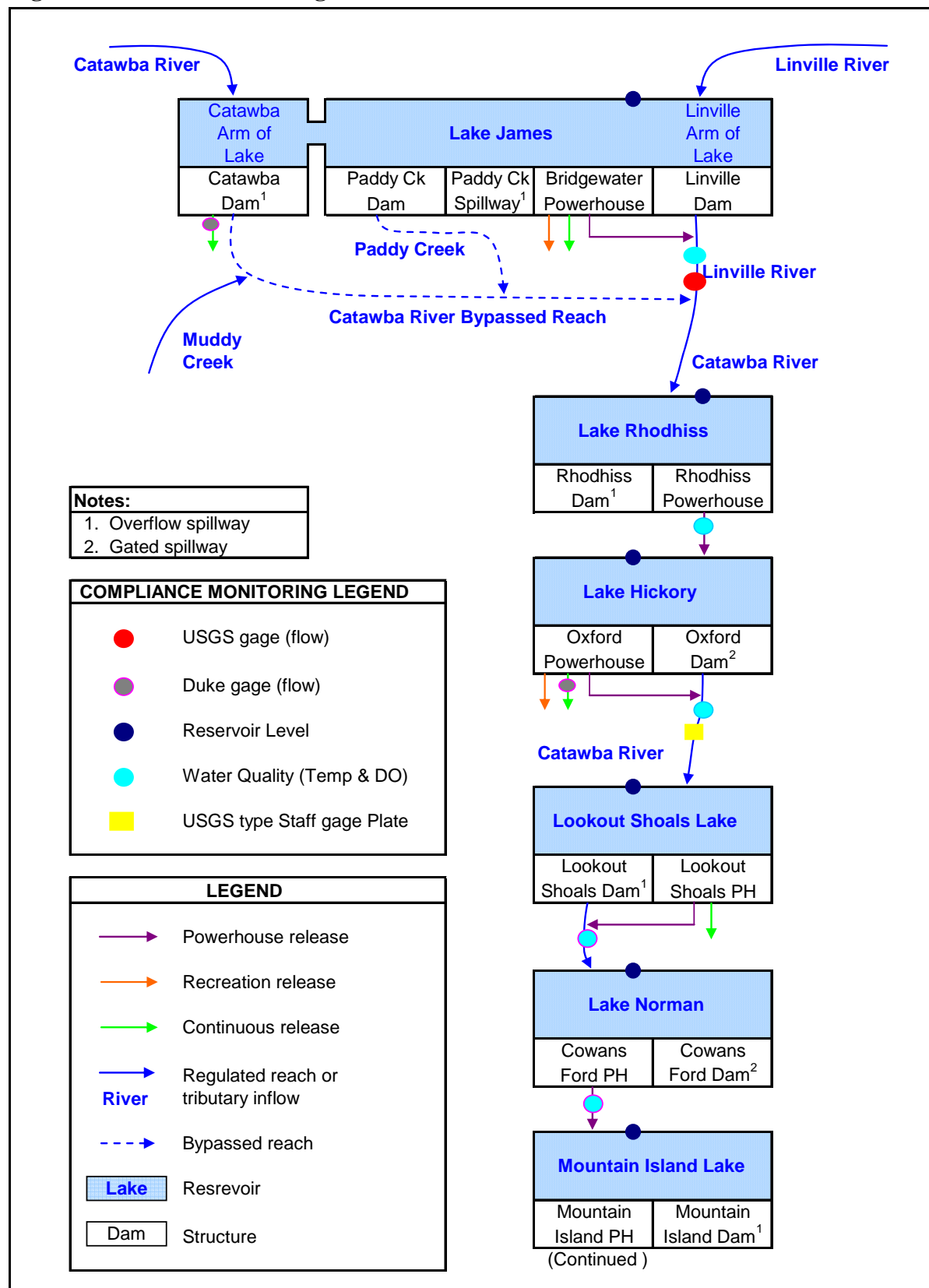
**Station Computer**

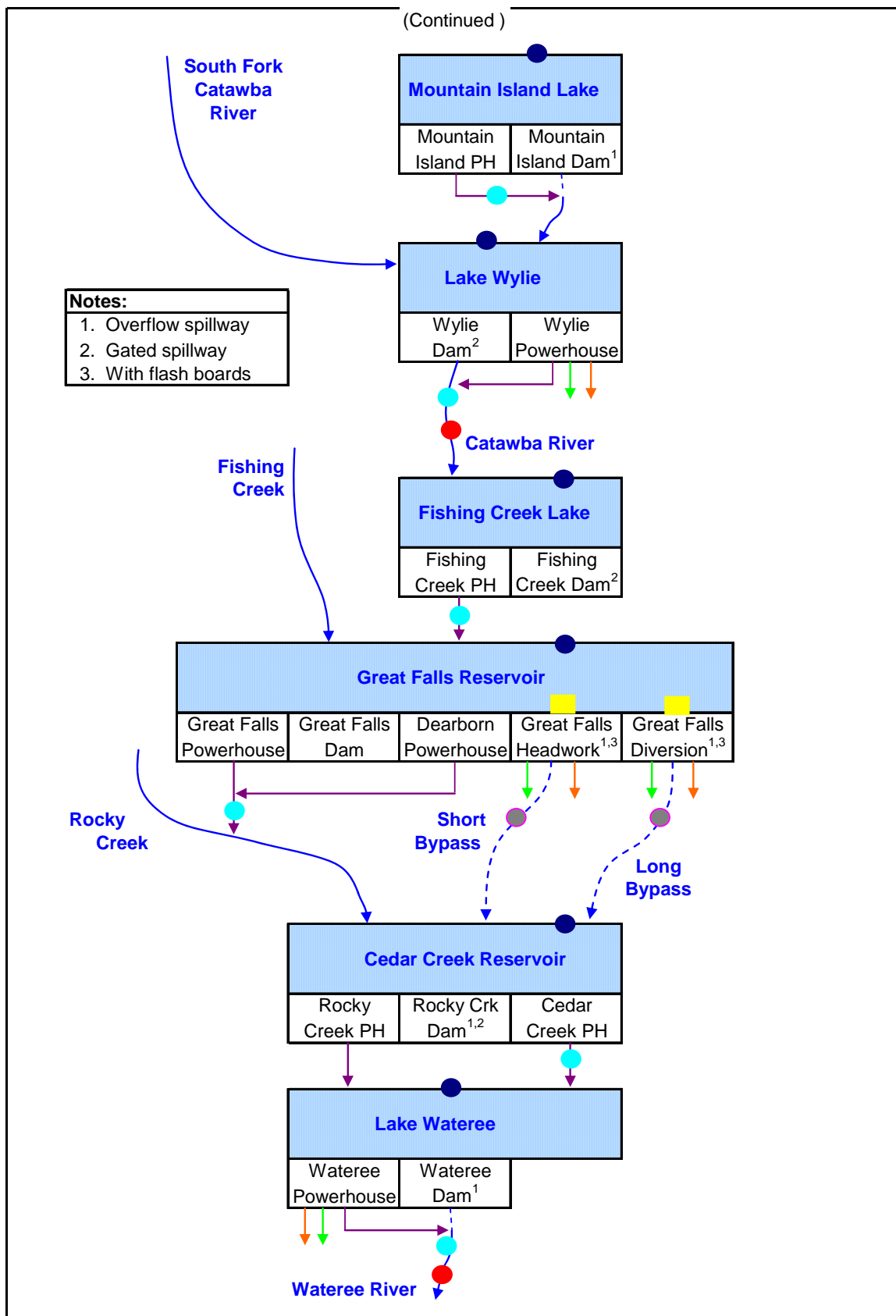
The tailrace water quality monitoring data is received by the current operating program at all Catawba Hydros, the system receives sensor input (all plant sensors) and displays the readings. The tailrace water quality monitoring data is integrated into plant operations and is part of the display that the operators are accustomed. In addition, the station computer serves as a backup database.

**PI Database**

This is the database currently used by Duke for storing all generation data from all facilities. PI has the ability to record and store data at specified intervals. Standard software extracts data from PI to be used in display formats for operators and/or reporting.

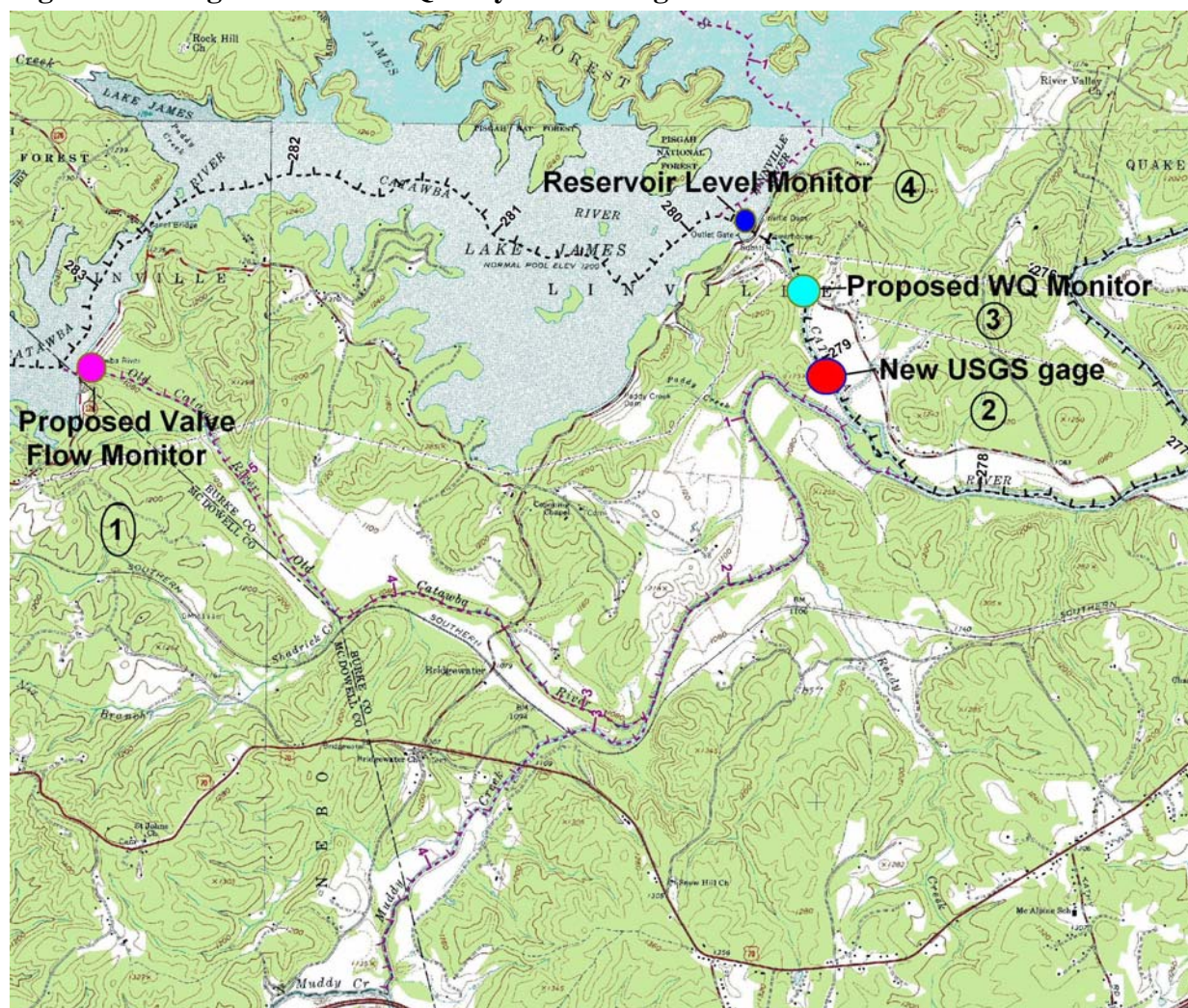
The first criterion for the placement of the water quality monitors follows the requirements of the Catawba-Wateree Comprehensive Relicensing Agreement. A schematic of the Catawba River (Figure 4) illustrates the various developments, water release points, and required monitoring locations.

**Figure 4: Schematic Drawing of the Catawba River**



The figures below show the proposed locations and discuss the rationale of the monitoring equipment location at each of the Catawba-Wataree Developments. The specific locations are based upon the criteria identified in Section A5.0 and downstream field testing.

**Figure 5: Bridgewater Water Quality Monitoring Location**



Map Location	Data	Recommended Location	Approximate Distance Downstream (miles)	Comments	Data Collection
1	Bypassed Reach Minimum Continuous Flows	Catawba Dam	0.00	Flow sensor at flow release valve	Wireless Telemetry to Station Computer and Staff Gage for Visual

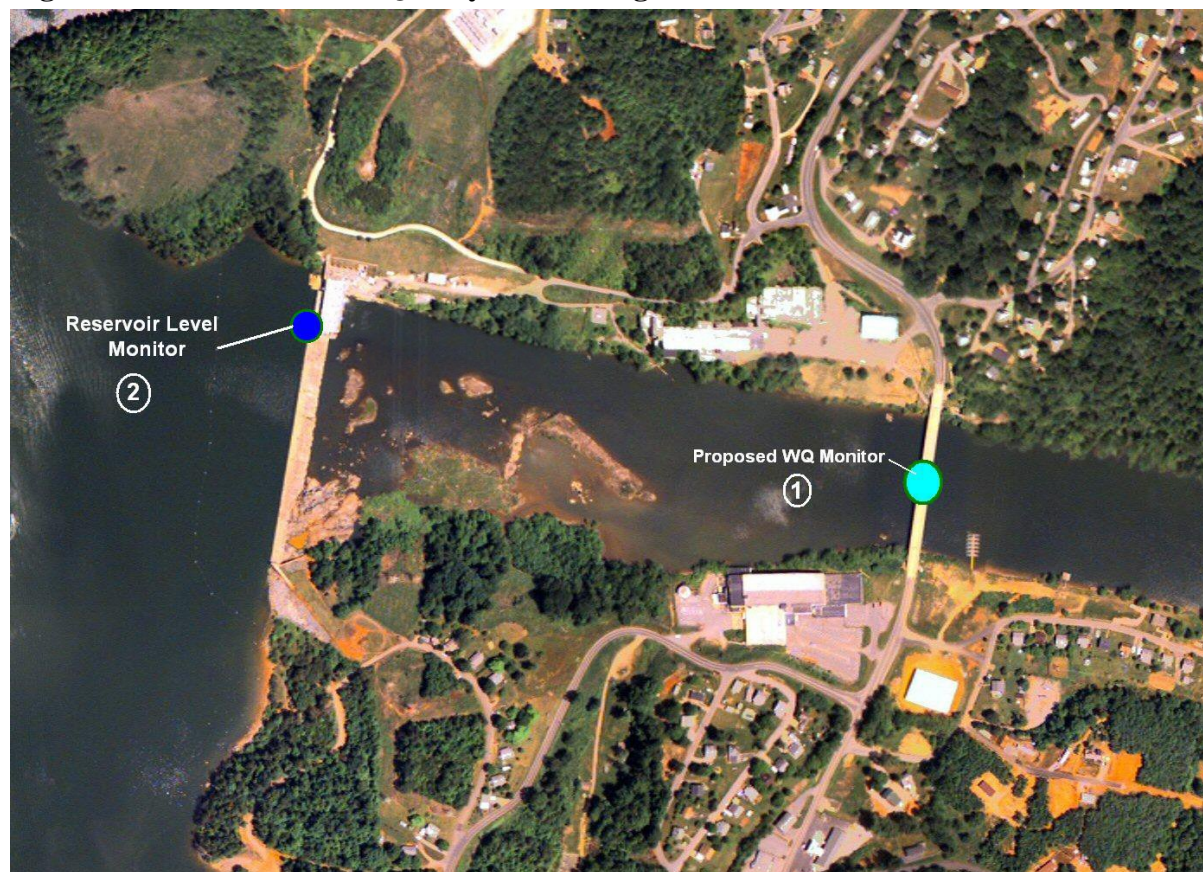
Map Location	Data	Recommended Location	Approximate Distance Downstream (miles)	Comments	Data Collection
2	Minimum Continuous Flows Recreational Flows Project Hourly Flows	Downstream of 1 <sup>st</sup> Bridge Powerhouse Road	0.65	USGS Gage (New Gage)	USGS Gage and Turbine Generation Records
3	Temperature Dissolved Oxygen	1 <sup>st</sup> Bridge Powerhouse Road Linville River Downstream Bridgewater Hydro	0.25	<i>In Situ</i> - Pipe and Instruments on Bridge (NCDOT approval required)	Wireless Telemetry to Station Computer
4	Reservoir Levels	Bridgewater Forebay	n/a	Current Device on the Intake Structure	Wired to Station Computer

### Device Location Rationale

The valve at the Catawba Dam will be designed to supply seasonal minimum continuous flows in the Catawba River Bypassed Reach (Location 1). A sensor in the flow pipe or valve, calibrated for flow, will provide a continuous reading of the flow being released into the Catawba River Bypassed Reach. Since the sensor is located directly on the valve or flow pipe, which is on the dam, the sensor should be secure from vandals.

The channel configuration at the proposed site for the new USGS gage is ideally suited for the expected range of flows originating from the Linville Dam. The site is located on private property providing a measure of security.

The previous water quality monitoring site was located on the downstream side of the powerhouse. Even though that site adequately represented the turbine flow water quality, the future configuration of the Bridgewater Powerhouse is not known, and, therefore, the recommendation for the future water quality monitoring location is at the first downstream bridge (on Powerhouse Road). The bridge provides an existing structure to place the water quality monitor in the center of the narrow river channel. The temporary monitors placed at this site during the Bridgewater downstream investigations (Knight 2003) illustrated similar water quality values to the tailrace monitor at all flows except the 50 cfs leakage flows that will be replaced by 75, 95 or 145 cfs minimum continuous flows in the future depending on the month. This site will represent the water quality conditions of any combination of hydro unit flow (including minimum flow). In addition, the site would be accessible under all Project flows, and would provide a rapid response at the station to water quality conditions. Security from vandals is a concern at this site.

**Figure 6: Rhodhiss Water Quality Monitoring Location**

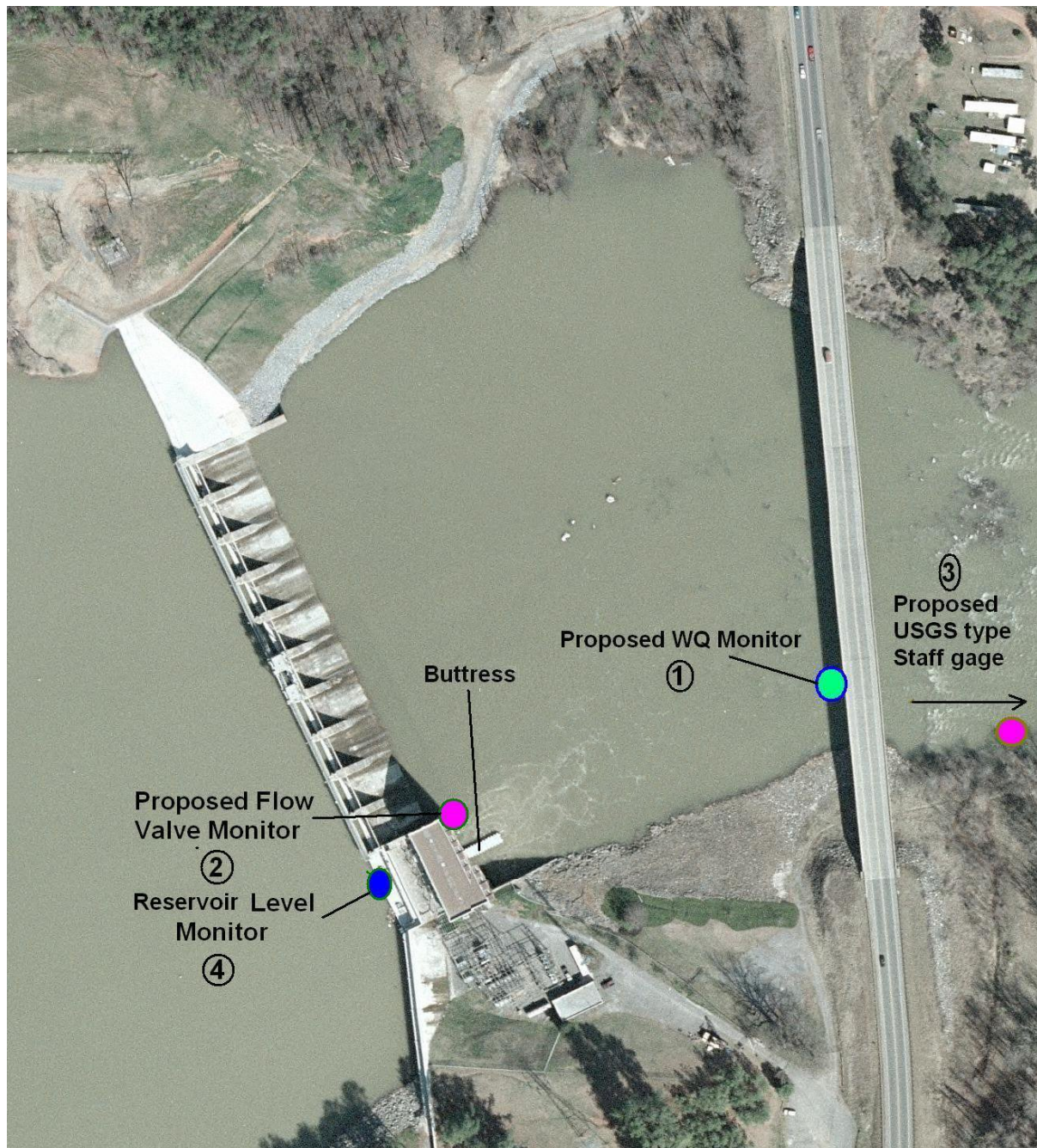
Map Location	Data	Recommended Location	Approximate Distance Downstream (miles)	Comments	Data Collection
1	Temperature Dissolved Oxygen	Rhodhiss Road Bridge Downstream Rhodhiss Hydro	0.35	<i>In Situ</i> - Pipe in Center of Channel and Instruments Mounted on Bridge (NCDOT approval required)	Wireless Telemetry to Station Computer
2	Reservoir Levels	Rhodhiss Forebay	n/a	Current Device on the Intake Structure	Wired to Station Computer

**Device Location Rationale**

The previous water quality monitoring site was located on the south corner on the downstream side of the powerhouse. That site adequately represented the water quality of the turbine flow when all the units were identical, however, the turbine venting tests (Duke Power 2005a), indicated that this location was not representative of the combined flows from units with differing aeration capability. Therefore, the monitor should be moved to the center of the river channel at the downstream bridge (Location 1). The bridge not only provides an existing

structure to place the water quality monitor in the center of the channel, but this site represents the water quality conditions of any combination of hydro unit flows (Duke Power, 2005a). This site is accessible under all Project flows, and may provide a rapid response at the station to water quality conditions. Security from vandals may be a slight concern at this site.

**Figure 7: Oxford Water Quality Monitoring Location**



Map Location	Data	Recommended Location	Approximate Distance Downstream (miles)	Comments	Data Collection
1	Temperature Dissolved Oxygen	Highway 16 Bridge Downstream Oxford Hydro	0.15	<i>In Situ</i> - Pipe South Channel and Instruments Mounted on Bridge (NCDOT approval required)	Wireless Telemetry to Station Computer
2	Minimum Continuous Flows	Oxford Dam	0.00	Flow sensor at flow release valve	Wireless Telemetry to Station Computer
3	Recreational Flows Project Hourly Flows	Riverbend Park Turbine Records	0.30	USGS-Type Plate Gage	Staff Gage for Visual and Turbine Generation Records
4	Reservoir Levels	Oxford Forebay	n/a	Current Device on the Intake Structure	Wired to Station Computer

### Device Location Rationale

An aerating flow valve will be designed to supply and measure a constant minimum continuous flow in the downstream channel (Location 2). A sensor in the discharge pipe or valve, calibrated for flow, will provide a continuous reading of the flow being released into the river channel. Since the sensor is located directly on the valve or flow pipe, which is on the dam, the sensor should be secure from vandals. The flow valve will provide the minimum continuous flow during periods of no hydro unit generation.

Generation and recreational flow requirements will be recorded from the generation records for each turbine. A manually read, USGS type plate staff gage will be placed at the boat put-in at Riverbend Park (Location 3) for independent verification.

The previous water quality monitoring site was located in the corner of the powerhouse and wingwall. That site adequately represented the water quality of the turbine flow when all the units were identical and prior to the recent installation of the tailrace buttresses. However, this site would probably not be representative of the combined flows from hydro units with differing aeration capability and the buttresses would effectively prevent Unit 2 water from reaching the sensor when Unit 1 was generating. Therefore, the monitor should be moved to the Highway 16 Bridge immediately downstream of the turbines (Location 1). The bridge not only provides an existing structure to place the water quality monitor in the channel, but this site will represent the water quality conditions of any combination of hydro unit flows. This site will be accessible under all Project flows, and will provide a rapid response of the station to water quality conditions. Security from vandals may be a concern at this site.

**Figure 8: Lookout Shoals Water Quality Monitoring Location**

Map Location	Data	Recommended Location	Approximate Distance Downstream (miles)	Comments	Data Collection
1	Temperature Dissolved Oxygen	East Wingwall - Tailrace	0.01	<i>In Situ</i> - Pipe, Monitor Location Unchanged	Wired to Station Computer
2	Minimum Continuous Flows Project Hourly Flows	Turbine Records	n/a	n/a	Turbine Generation Records
3	Reservoir Levels	Lookout Forebay	n/a	Current Device on the Intake Structure	Wired to Station Computer

Device Location Rationale

The minimum continuous flow will be provided by either one of the small auxiliary hydro units (Location 2) during periods when the larger hydro units are not operating. The configuration of the Lookout Shoals tailrace (large pool upstream of first downstream hydraulic control) exhibits very little stage change with or without the auxiliary hydro unit generation. In addition, the

elevation of the tailrace is also a function of Lake Norman's reservoir level (at full pond, the reservoir level extends upstream of the hydraulic control). Therefore, the minimum continuous flow and hourly flow rates would be best monitored by the individual generation records of each hydro unit at Lookout Shoals Hydro.

The previous water quality monitoring site was located on the east wingwall downstream of Unit 1. That site adequately represented the water quality of the turbine flow when all the hydro units were identical. The nearest downstream structure to place a monitor in the center of the channel is the I-40 Bridge which is 1.3 miles downstream. The I-40 Bridge site is strongly influenced by Lake Norman's reservoir level, and the long travel time of the minimum flow would influence the water quality at minimum flow. Therefore, the I-40 Bridge location is not preferred for water quality monitoring. Since no other downstream structure exists to place a monitor in the center of the river, the wingwall site (Location 1) represents the best logistical option available for water quality monitoring. This wingwall site will be accessible under all Project flows, and will provide a rapid response of the station to water quality conditions. The monitor will be secure since it is located inside the security fence.

**Figure 9: Cowans Ford Water Quality Monitoring Location**



Map Location	Data	Recommended Location	Approximate Distance Downstream (miles)	Comments	Data Collection
1	Temperature Dissolved Oxygen	Railroad Bridge Downstream Cowans Ford Hydro	0.50	<i>In Situ</i> - Pipe West Channel and Instruments Mounted on Bridge (Railroad approval required)	Wireless Telemetry to Station Computer
2	Reservoir Levels	Cowans Ford Forebay	n/a	Current Device on Intake Structure	Wired to Station Computer

#### Device Location Rationale

Even though the previous monitor was placed on the tail-deck of the hydro, this location probably represented the water quality of the released flow. However, under multi-unit operation, the monitor would only record data from the hydro unit flows adjacent to the monitor. In addition, security at the Cowans Ford Hydro facility is controlled by the McGuire Nuclear site (Nuclear Regulatory Commission guidelines) and is difficult to enter when operators are not present. This security issue limits maintenance accessibility. Therefore, the recommended site for the future temperature and dissolved oxygen monitoring is at the railroad bridge 0.5 miles downstream (Location 1). This site would enable the monitor to measure water quality from the high-volume hydro unit flow as well as provide a somewhat secure and accessible site. Location of the monitor just west of the downstream tip of the island would insure that the monitor would be out of the influence of the wastewater discharge from McGuire Nuclear Station.

**Figure 10: Mountain Island Water Quality Monitoring Location**

Map Location	Data	Recommended Location	Approximate Distance Downstream (miles)	Comments	Data Collection
1	Temperature Dissolved Oxygen	Tail Deck - Tailrace	0.00	<i>In Situ</i> - Pipe, Monitor Location Unchanged	Wired to Station Computer
2	Reservoir Levels	Mt. Island Forebay	n/a	Current Device on Intake Structure	Wired to Station Computer

#### Device Location Rationale

Even though the present monitor is on the tail-deck of the hydro (Location 1), this location probably represents the water quality of the released flow. However, under multi-unit operation, the monitor would only record data from the hydro unit flows adjacent to the monitor. Since no other structure, (e.g., bridge), exists in the center of Mountain Island's tailrace, this tail-deck location represents the best logistical location available. It is secure and provides ready access for maintenance.

**Figure 11: Wylie Water Quality Monitoring Location**

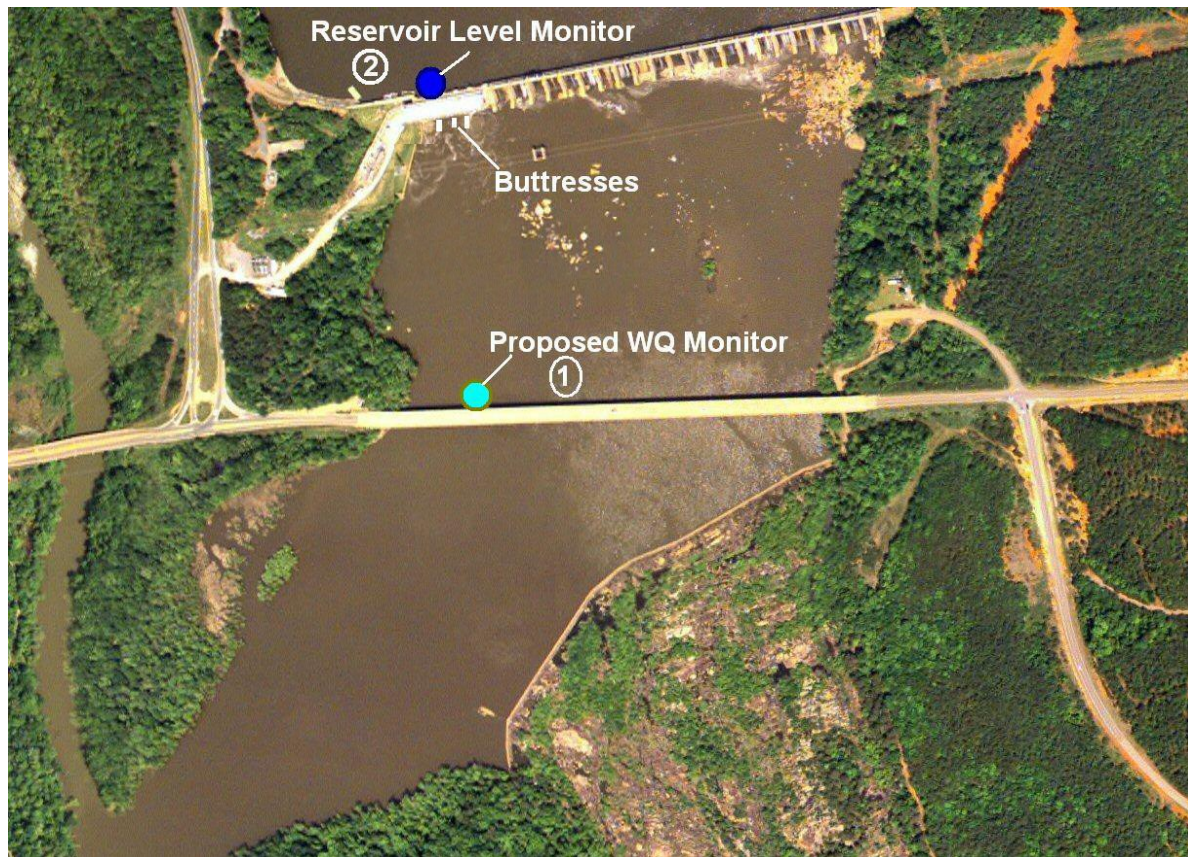
Map Location	Data	Recommended Location	Approximate Distance Downstream (miles)	Comments	Data Collection
1	Temperature Dissolved Oxygen	~ ½ mile Downstream from Hydro (pier on Ferrell Island)	0.50	Flow-Through System Auto Calibration Sensor (Island property owner's approval required)	Wireless Telemetry to Station Computer
2	Minimum Continuous Flows	Small Unit Turbine Records Highway 21 USGS Gage	0.00 3.60	USGS Gage (Catawba River near Rock Hill, SC) (02146000)	USGS Gage and Turbine Generation Records

Map Location	Data	Recommended Location	Approximate Distance Downstream (miles)	Comments	Data Collection
3	Recreational Flows Project Hourly Flows	Turbine Records Highway 21 USGS Gage	0.00 3.60	USGS Gage (Catawba River near Rock Hill, SC) (02146000)	USGS Gage and Turbine Generation Records
4	Reservoir Levels	Wylie Forebay	n/a	Current Device on the Intake Structure	Wired to Station Computer

#### Device Location Rationale

The USGS gage at the Highway 21 Bridge (Location 2/3) is well established and will be used for verification of minimum continuous flow, recreational flows, and hourly Project flows. In addition, generation records will be used to supplement the USGS data.

The previous water quality monitoring site was located in the corner of the powerhouse and wingwall. Extensive monitoring of dissolved oxygen concentrations in the Wylie tailrace was conducted during the 2002 turbine venting test (Duke 2005a). These results indicated that the proposed monitoring location was the closest point to the hydro that best represented the water quality of the multi-unit flows (Location 1). This test included detailed water quality sampling along several downstream transects, as opposed to just at the monitoring site. Furthermore, the Wylie tailrace is very complicated since the island immediately downstream of the powerhouse splits the water released from the hydro. The flow, from either a single unit or multiple unit operation, moves around the island and finally merges just upstream of the small island across the channel from the proposed monitoring location. Use of this location is contingent on being able to get permission for access from the property owner and on obtaining any necessary easements. Security from vandals is of some concern at this site.

**Figure 12: Fishing Creek Water Quality Monitoring Location**

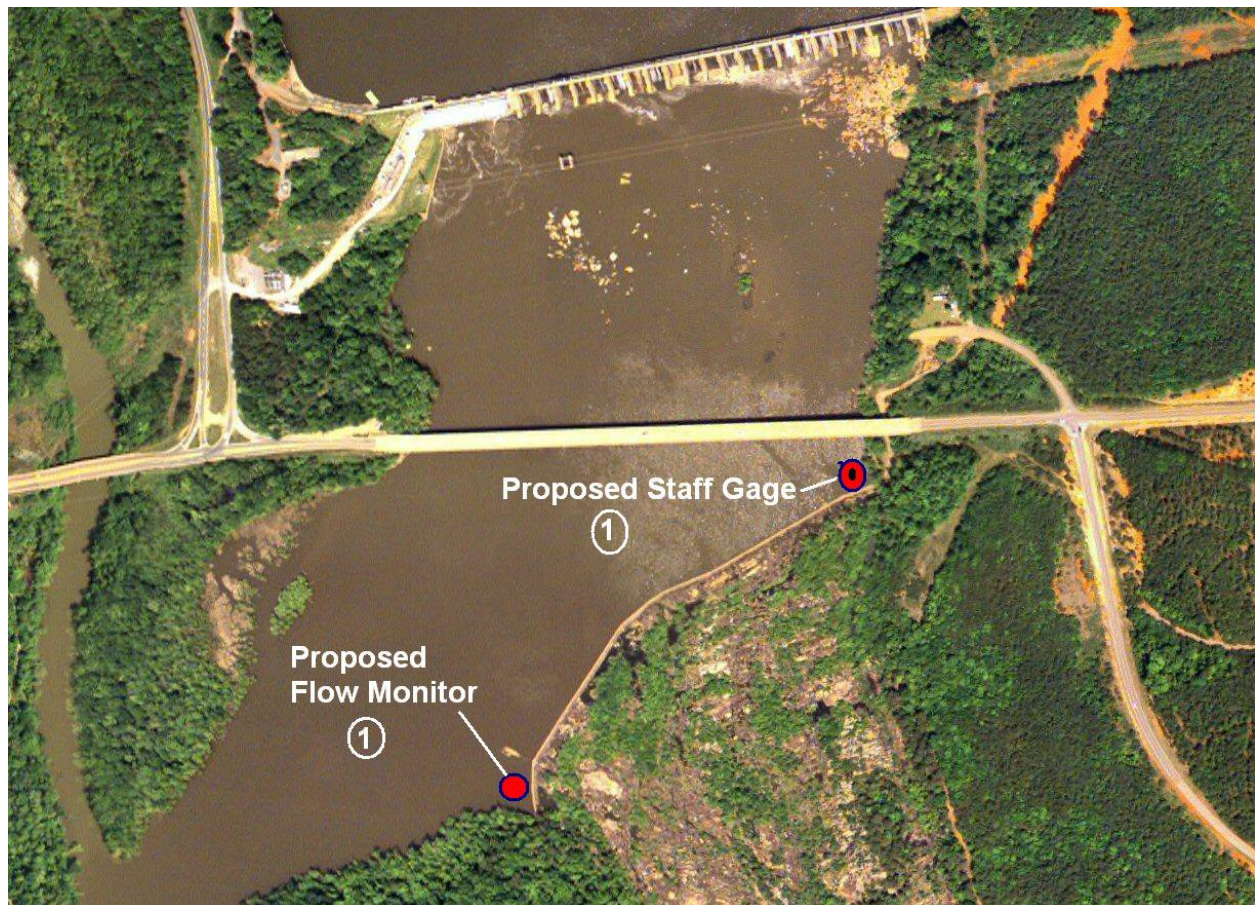
Map Location	Data	Recommended Location	Approximate Distance Downstream (miles)	Comments	Data Collection
1	Temperature Dissolved Oxygen	Highway 97/200 Bridge Downstream Fishing Creek Hydro	0.15	<i>In Situ</i> - Pipe West Channel and Instruments mounted on Bridge (SCDOT approval required)	Wireless Telemetry to Station Computer
2	Reservoir Levels	Fishing Creek Forebay	N/A	Existing Device on the Intake Structure	Wired to Station Computer

#### Device Location Rationale

The previous water quality monitoring site was located on the wingwall, west of the Fishing Creek Powerhouse. That site adequately represented the water quality (temperature and dissolved oxygen) of the turbine flow when all the hydro units were identical and prior to the recent installation of the tailrace buttresses. However, this site would probably not be representative of the combined flows from hydro units with differing aeration capability since

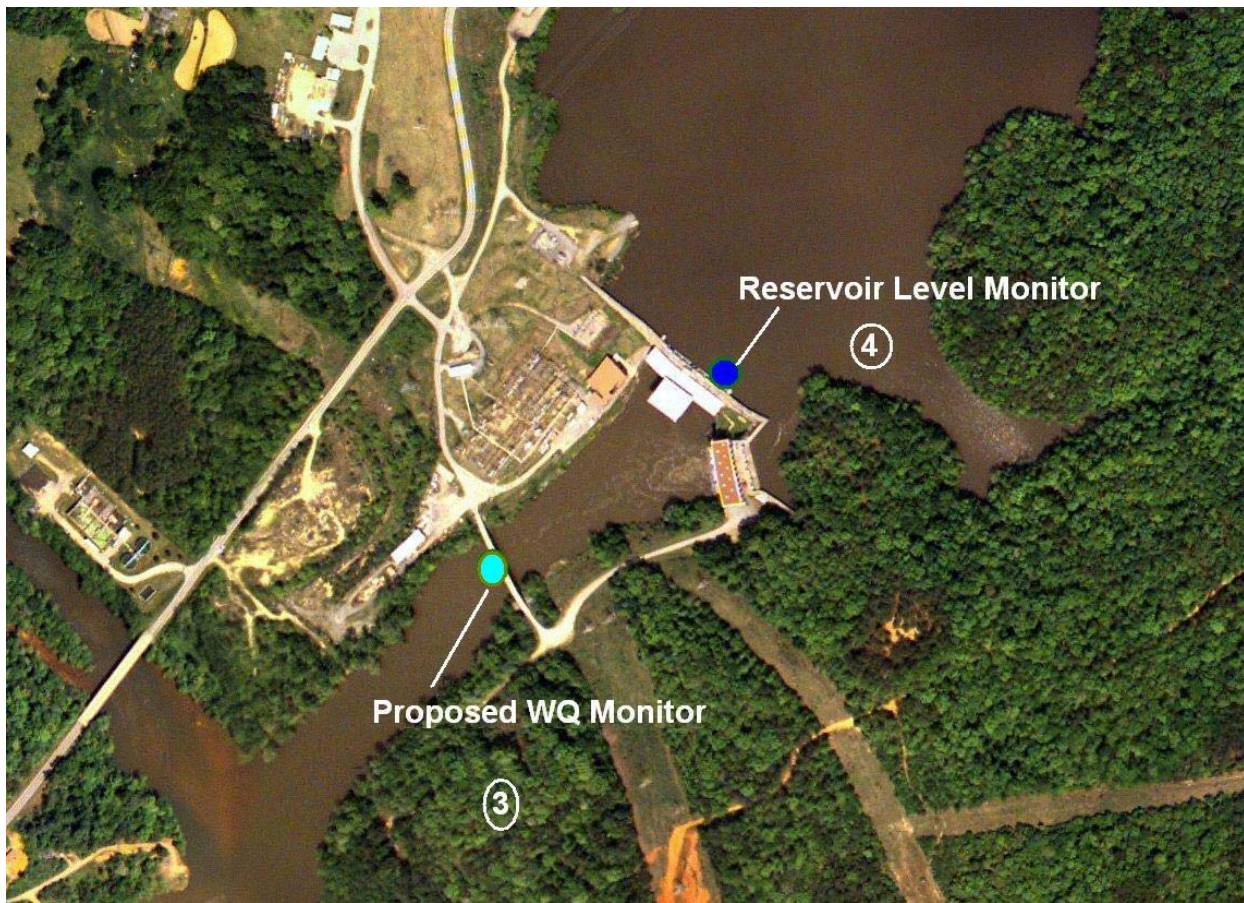
the flows will be directed downstream due to the newly installed buttresses. Therefore, the monitor will be moved to the Highway 97/200 Bridge immediately downstream of the turbines (Location 1). The bridge not only provides an existing structure to place the water quality monitor in the channel, but this site will represent the water quality conditions of any combination of hydro unit flows. This site is accessible under all Project flows, and will provide a rapid response of the station to water quality conditions. Security from vandals may be a concern at this site.

**Figure 13: Great Falls-Dearborn Water Quality Monitoring Location - Diversion Dam**



**Figure 13 (cont'd): Great Falls-Dearborn Water Quality Monitoring Location - Headworks**



**Figure 13 (cont'd): Great Falls-Dearborn Water Quality Monitoring Location - Main Dam**

Map Location	Data	Recommended Location	Approximate Distance Downstream (miles)	Comments	Data Collection
1	Bypassed Reaches Minimum Continuous Flows Recreational Flows	Diversion Dam Long Bypassed Reach Downstream Fishing Creek Hydro	0.25 mi. from Fishing Creek Dam	Pressure Sensor calibrated to correspond to minimum continuous flow pond level. Pressure Sensor calibrated to correspond to recreational flows and pond level.	Wireless Telemetry to Station Computer and Staff Gage for visual
2	Bypassed Reaches Minimum Continuous Flows	Headworks Short Bypassed Reach Downstream Fishing Creek	1.95 mi. from Fishing Creek Dam	Gate Position Sensor calibrated to gate opening corresponding	Wireless Telemetry to Station Computer and

Map Location	Data	Recommended Location	Approximate Distance Downstream (miles)	Comments	Data Collection
	Recreational Flows	Hydro		to minimum continuous flow. Pressure Sensor calibrated to correspond to recreational flows and pond level.	Staff Gage for visual
3	Temperature Dissolved Oxygen	Duke Bridge Downstream of Hydros	0.1 mi. from Great Falls – Dearborn Dam	<i>In Situ</i> - Pipe, Monitor Location Unchanged	Wired to Station Computer
4	Reservoir Levels	Great Falls Forebay	N/A	Existing Device on the Intake Structure	Wired to Station Computer

### Device Location Rationale

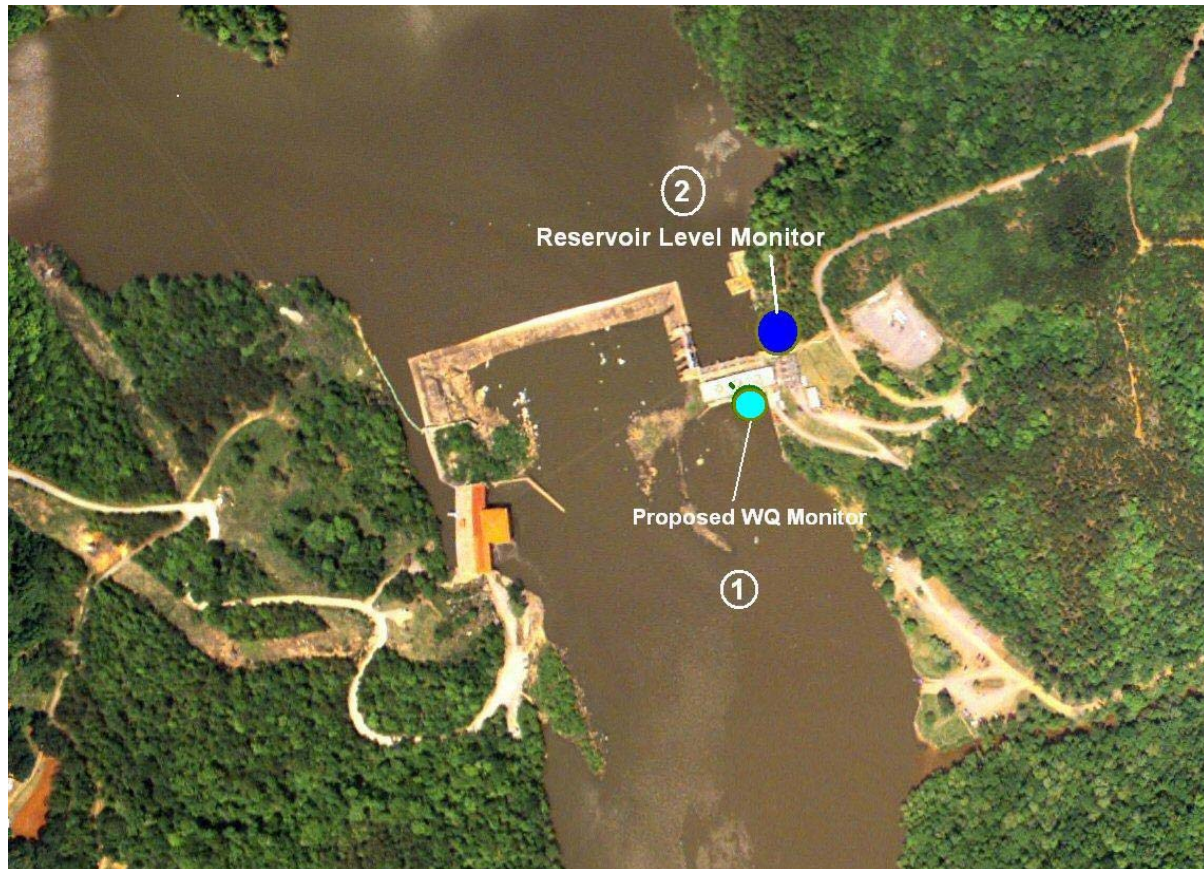
Ideally, measurement of the minimum continuous flows and recreational flows in the Great Falls Long and Short Bypassed Reaches would be taken directly in the respective channels. However, the irregular channel configuration in both reaches prevents accurate flow measurements from stage changes. In addition, the difficult access to the bypassed reaches poses substantial personnel safety limitations to the calibration and maintenance of the gages. Therefore, the best measurement of the flow in the bypassed reaches is at the source of the flows (Locations 1 and 2).

Although the exact design of the minimum continuous flow delivery mechanism has not been completed, the measurement of flow will be a stage-discharge relationship between the pond level and the flow being delivered. Continuous flow monitoring for the Long Bypass will be located at the Great Falls Diversion Dam immediately downstream of Fishing Creek Hydro (Location 1). The continuous flow monitoring for the Short Bypassed Reach will be provided at the Great Falls Headworks spillway, both upstream and downstream of the headworks structure (hence a flow measurement system upstream and downstream of the headworks) (Location 2).

Recreational flows will be provided as spill over the Great Falls Diversion Dam and the Great Falls Headworks. Again, the water level over the spillways will be measured and stage-discharge equations will relate stage to flow. Manually read, new USGS type plate staff gages will be placed at the Great Falls Diversion Dam and upstream of the Great Falls Headworks.

The previous water quality monitor mounted on the Duke Energy bridge immediately downstream of Great Falls and Dearborn Hydros is ideally located since it is in the center of the channel (Location 3). This position captures the water quality (temperature and dissolved oxygen) from both hydros and is in a secure location.

**Figure 14: Cedar Creek Water Quality Monitoring Locations**



Map Location	Data	Recommended Location	Approximate Distance Downstream (miles)	Comments	Data Collection
1	Temperature Dissolved Oxygen	Downstream Face of Cedar Creek Powerhouse	0.00	<i>In Situ</i> - Pipe, Monitor Location Unchanged	Wired to Station Computer
2	Reservoir Levels	Cedar Creek Forebay	n/a	Current Device on the Intake Structure	Wired to Station Computer

#### Device Location Rationale

The previous water quality monitor is located in the center of the Cedar Creek tailrace. It was mounted directly on the powerhouse. Since the hydro units at Cedar Creek were identical, the

temperature and dissolved oxygen monitor adequately measured the water quality released from Cedar Creek Powerhouse (Location 1).

The water quality of the Cedar Creek hydro flow represents the overall tailrace water quality since:

- Cedar Creek Powerhouse flow is significantly greater than Rocky Creek Powerhouse flow and dominates the downstream flow (capacity of Cedar Creek units is three times the capacity of the Rocky Creek units).
- Rocky Creek Hydro is operated infrequently; it is operated only after Cedar Creek Reservoir pond level cannot be maintained by Cedar Creek Hydro (three Units at Cedar Creek).
- Both hydros draw water from the same forebay and the water quality is similar.

Thus, no water quality monitoring device is necessary at the Rocky Creek Hydro. Unlike Great Falls-Dearborn, there is no structure downstream of Cedar Creek Powerhouse to mount a water quality monitor in the center of the channel.

**Figure 15: Wateree Water Quality Monitoring Locations**

Map Location	Data	Recommended Location	Approximate Distance Downstream (miles)	Comments	Data Collection
1	Temperature Dissolved Oxygen	West Platform – Tailrace	0.02	Probably Flow-Through System Auto Calibration Sensor	Wired to Station Computer
2	Minimum Continuous Flows	Highway 1/601 USGS Gage	7.4	USGS Gage (Wateree River near Camden, SC) (02148000)	USGS Gage and Turbine Generation Records

Map Location	Data	Recommended Location	Approximate Distance Downstream (miles)	Comments	Data Collection
3	Recreational Flows Project Hourly Flows	Turbine Records Highway 1/601 USGS Gage	7.4	USGS Gage (Wateree River near Camden, SC) (02148000)	USGS Gage and Turbine Generation Records
4	Reservoir Levels	Wateree Forebay	n/a	Current Device on the Intake Structure	Wired to Station Computer

#### Device Location Rationale

The USGS gage at Highway 1/601 (Location 2/3) is well-established and will be used for verification of minimum continuous flow, recreational flows, and hourly Project flows. Generation records will be used to supplement the USGS data.

The Wateree tailrace is a relatively simple channel, with the flows from the various hydro units moving directly downstream. However, the tailrace does not lend itself to simple water quality monitoring due to the various aeration capabilities of the individual hydro units and subsequent multi-unit flow patterns (Duke Power 2005a). Moving the monitor location downstream to capture a multi-unit flow is not an option because, at flows greater than provided by 2-3 unit operations, a significant volume of water flows out of the main channel to the east within a few hundred yards of the powerhouse.

The existing monitor location (Location 1) was built to extend a short distance into the tailrace with the goal of better measurements than at the face of the powerhouse. The existing monitor location is the best logistical location available to measure water quality because no structure exists in the center of the channel, nor is the east side of the channel a viable option because that area is heavily used by fisherman (creating damage and security issues) and is prone to flooding and further potential damage or loss.

The next available location at the Highway 1/601 Bridge is not suitable because of its distance from the Powerhouse and the presence of aquatic plants and shoals between the Powerhouse and bridge that significantly influence the DO levels.

## **B2.0 Sampling Methods**

All dissolved oxygen and temperature data will be collected *In Situ* using submerged instruments within standpipes attached to a permanent structure in the tailrace. The instruments will be powered by an external power source and data transmitted to the station operational computer. The data are available in real-time for operational decisions regarding aeration.

The tailrace data will be collected between April 1 and November 30 each year, with an annual report available June 30 of the following year. This monitoring period was selected based upon the 10-year monitoring presented in the License Application. At no time were dissolved oxygen concentrations less than 5 mg/l during the period December through March.

**B3.0 Sample Handling and Custody**

No samples will be collected, transported, or stored since all dissolved oxygen and water temperature measurements will be recorded *in situ*.

**B4.0 Analytical Methods**

The Winkler determination for dissolved oxygen is the only chemical analytical method employed for the monitoring. This technique forms the basis of all instrument calibrations.

**B5.0 Quality Control**

Quality control measures for Dissolved Oxygen and Temperature measurements will include proper calibration and regular tracking and servicing of instruments (see Sections B6 and B7). Quality assurance activities include documentation of field procedures, data back-up, automatic data logging, training, etc.

**B6.0 Instrument/Equipment Testing, Inspection, and Maintenance**

The Monitoring Field Manager is responsible for establishing the proper procedures for testing, inspection, calibration, and maintenance of all water quality instruments. The procedures will include a thorough evaluation of instrument performance; evaluations will include sensor response times for large concentration differences and linearity checks of instrument calibration from less than 10% DO saturation to greater than 100% saturation.

Quality control charts will be maintained for each instrument (tracked by serial number) for response times and linearity over the lifetime of the instrument. In addition to obvious problems, these charts will be used to evaluate the suitability of instrument deployment, instrument repair, and/or return for manufacturer servicing.

All maintenance and servicing of instruments will be recorded by the field staff in a maintenance log book and in an established electronic format.

**B7.0 Instrument/Equipment Calibration and Frequency**

Calibration of the Dissolved Oxygen Sensor(s) consists of either a primary calibration or a secondary calibration.

**Primary Dissolved Oxygen Calibration**

This calibration consists of adjusting an instrument to read at the primary standard concentration (manufacturer calibration method). This calibration is performed in the laboratory by adjusting all instruments to a known concentration of oxygen, as determined by the Winkler method. Each instrument, prior to deployment in a tailrace, shall be calibrated to the Winkler standard.

### Secondary Dissolved Oxygen Calibration

This calibration is reserved for evaluation of whether an instrument that has been deployed shall remain deployed or taken back to the laboratory for maintenance. One designated instrument (primary calibration performed that same day) shall be used at all sites that day to compare its readings side-by-side with the deployed. If the differences between the two instruments are greater than the manufacturers' tolerances, the deployed instrument shall be calibrated to the recently calibrated instrument. If the deployed instrument does not calibrate or the differences are greater than the control chart limits (see next paragraph), the deployed instrument shall be returned to the laboratory for maintenance and be replaced with a recently calibrated (primary) instrument.

Quality control charts shall be maintained for all comparisons of instruments. These charts shall be maintained by individual instruments and by location. This data shall be used to determine the limits of out of calibration tolerance for instrument field calibration criteria.

Initially, calibrations and checks on calibration will be conducted weekly. However, over time the quality control charts will be used to adjust calibration frequency, especially if the technologically advanced sensors require far less maintenance than conventional sensors.

### **B8.0 Inspection/Acceptance of Supplies and Consumables**

The Monitoring Field Manager approves all orders for supplies required for instrument maintenance and calibration. Upon receipt, all supplies will be inspected for damage. All supplies and equipment ordered will be stored and documented in accordance with Duke's Chemical Inventory and approved through Duke's chemical approval process.

### **B9.0 Non-Direct Measurements**

Measurement data not obtained directly under the DO Monitoring Plan and this QAPP, including hydro plant generating data, reservoir elevation data, National Weather Service weather data, and U.S. Geological Survey (USGS) gage stream flow data, may be used for interpretation of continuous DO monitoring data. Data collected by regulatory and governmental agencies will be used and considered as valid data since these agencies have independent QA/QC programs to ensure valid data. Catawba-Wateree Project generation data will be acquired through Duke Energy's Hydro Fleet Operations.

Data from universities, non-governmental organizations, or industries may be used to analyze continuous monitoring results depending upon methods, sampling design, and QA/QC limitations. Citations will be made when such data are used.

### **B10.0 Data Management**

The continuous DO and water temperature data are collected and monitored on a real time basis. As the sensor detects the concentrations, the data is automatically transmitted to the PI data system via the station computer. The PI database provides for permanent records storage while the station computer temporarily stores the data should the transfer link to the PI system fail.

Once in the PI data system, the data, or its derivatives, will be provided to Duke's real time Hydro Operations Center.

The protocol for data transmission, storage, and retrieval is controlled by the Plant Information (PI) database management team. Data files are stored for the duration of the project on the PI data server, which is backed up electronically on a daily basis.

## **GROUP C – ASSESSMENT AND OVERSIGHT**

### **C1.0 Assessment and Response Actions**

The Monitoring Field Manager or a qualified QA/QC Auditor appointed by the Monitoring Field Manager will perform an annual (after the field monitoring season) internal self-assessment of the QA program to ensure the QA/QC records are complete and accountable. The self-assessment results will be documented and provided to the Duke PM/QA Manager for the project QA/QC files. Any corrective actions, as required, will be implemented and documented.

The Duke PM/QA Manager provides additional oversight through the review of the QA/QC records generated for the continuous DO and water temperature monitoring. The Duke PM/QA Manager will review and verify field data collection, data processing and data file submittals; submittal of QA records to the QA/QC file; corrections or revisions to data files and any subsequent documentation in the QA/QC file; and self-assessment results.

The Monitoring Field Manager will observe the field techniques of the Field Staff at periodic intervals throughout the monitoring season. Any issues with technique will be corrected at that time and documented in the appropriate field log book.

### **C2.0 Reports to Management**

The process for reporting significant issues will follow a chain of command structure. The Monitoring Field Manager will report problems to the Duke PM/QA Manager and will address the problem.

The Duke PM/QA Manager will receive annual reports, copies of log books, and calibration forms for review and will ensure that these records are maintained in a designated QA/QC file.

## **GROUP D – DATA VALIDATION AND USABILITY**

### **D1.0 Data Review, Verification, and Validation**

Throughout the monitoring season, the Monitoring Field Staff or Monitoring Field Manager will periodically transfer data from the PI system to software designed to perform provisional data summaries and trend analysis. Calibration and maintenance data will be incorporated into this program/database.

The Monitoring Field Manager will review this data for completeness and flag suspect data and/or evaluate anomalies, trends, compliance issues, etc and will provide the provisional data,

along with recommendations, to the Duke PM/QA Manager after it is processed. Only the Monitoring Field Manager has access to the database to change or correct data. The Monitoring Field Manager will provide the Duke PM/QA Manager with a copy of the final Annual Database at the end of the field monitoring season. Supporting calibration forms and maintenance records will be transferred to the Duke PM/QA Manager.

## **D2.0 Verification and Validation Methods**

Throughout the entire monitoring season the database is archived systematically to ensure no loss of data and to guarantee database integrity. At the end of the field monitoring season, all forms, original data, and the database will be archived in electronic format on digital media; and stored in an electronic storage format as well as by the Duke PM/QA Manager.

## **D3.0 Reconciliation with User Requirements**

The real time data will be available in the Hydro Operating Center which will be displayed with real-time trending analysis “process book” and PI related calculation tools. The real time presentation allows for quick identification of instrument and or operational issues with the data and allows for immediate problem identification and resolution.

Data collected during the Catawba-Wataree Compliance Monitoring program will be used to adjust hydro operations to comply with the requirements of the 401 Water Quality Certification and the FERC license and provide water quality data for reporting compliance, and/or non-compliance events to appropriate agencies, as well as conducting on-going evaluations regarding equipment performance and operational guidelines.

In the event that anomalies are found in the data, the Duke PM/QA Manager will review the field notes taken by the Monitoring Field Manager and look for storm events or unusual watershed conditions and assess their effects on data.

Data collected for each monitoring season will be put in report form and provided to NCDWQ, SCDHEC, Duke and FERC, as well as archived in the PI system. Any anomalies and analysis for any peaks or changes in data throughout the year will be documented in the reports provided by the Field Manager to the Duke PM/QA Manager. Any sampling design modifications will be considered only after consultation with NCDWQ/SCDHEC.

## REFERENCES

- Duke Energy. 2006. *Catawba-Wateree Project FERC # 2232 Application for New License Exhibit E – Water Quantity, Quality, and Aquatic Resources, Study Reports*. Duke Energy. Charlotte, NC.
- United States Environmental Protection Agency. 2001. *EPA Requirements for Quality Assurance Project Plans*. EPA QA/R-5, EPA/240/B-01/003. USEPA, Office of Environmental Information, Washington D.C.
- Wagner, R. J., H. C. Matraw, G. F. Ritz, and R. A. Smith. 2000. *Guidelines and Standard Procedures for Continuous Water-Quality Monitors: Site Selection, Field Operation, Calibration, Record Computation, and Reporting*. U. S. Geological Survey, Water-Resources Investigations Report 00=4252. Reston, Virginia.

## **APPENDIX A-QAPP**

### **Standard Operating Procedures For *In Situ* Compliance Monitoring**

(To be completed upon receiving equipment and manufacturer's operating manuals)

1. Laboratory Evaluation of Water Quality Sensor Performance  
(Make sure sensor performs as designed)
2. Configuration and Calibration of Water Quality Sensors Prior to Field Deployment  
(Setup and calibration of instrument before deployed in tailrace)
3. Determination of Dissolved Oxygen Using the Winkler Method  
(Used for laboratory calibration of sensors)
4. Routine Maintenance of Water Quality Sensor after Field Deployment  
(Cleaning, troubleshooting, and storing instrument between field deployments)
5. In-field Instrument Performance Check, Calibration, and Criteria for Instrument Replacement  
(Verification of instruments calibration while deployed and/or instrument replacement)

## APPENDIX B-QAPP

### Bridgewater Development

#### Supplemental Trout Habitat Monitoring

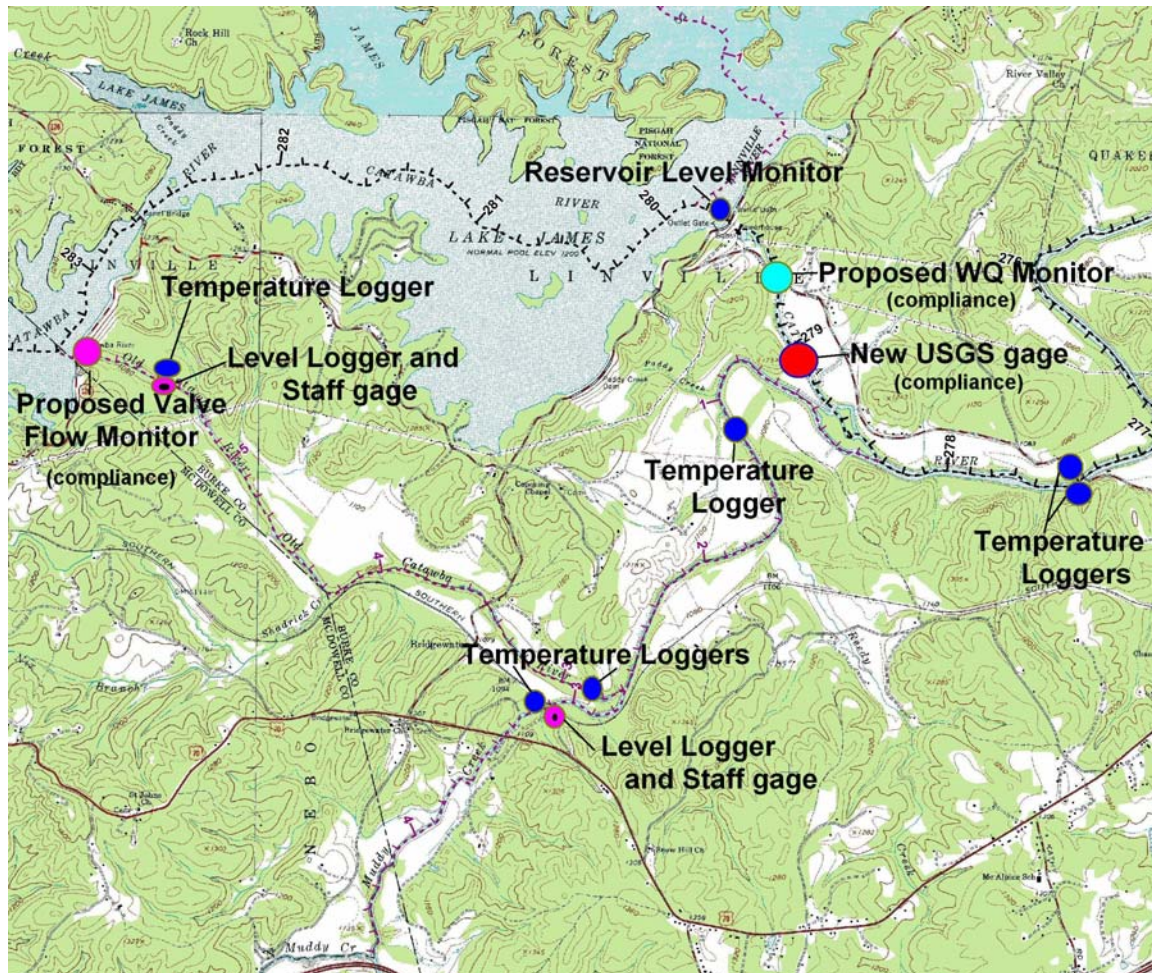
The Catawba River Bypassed Reach and Bridgewater minimum continuous flows have been selected and evaluated to provide flows and water temperatures suitable for protection and enhancement of mussels in the bypassed reach and the maintenance of a stocked trout fishery downstream of Bridgewater Hydro. The volume of warm water flows provided to the Catawba River Bypassed Reach to maintain mussel habitat are balanced against the coldwater minimum flow from the Linville Dam to maintain suitable temperatures for trout downstream of the confluence of the Catawba River Bypassed Reach and the Linville River. The flows and temperatures provided to each channel to achieve the desired, but conflicting temperature requirements were analyzed by the CE-QUAL-W2 reservoir model and the River Modeling System (RMS). The results of these computer models were evaluated by the Aquatics/Terrestrial and Water Quality Resource Committees. Bypassed Reach and Linville Dam minimum continuous flows stated in the CRA are the result of the recommendations from the evaluations by the resource committees.

#### Monitoring

Due to the hydraulic complexity and apparent conflicts of resource management interests (differing trout and mussel temperature preference) in this area, supplemental monitoring will be used to support future evaluations of whether trout management goals in the main stem Catawba River continue to be supported. This supplemental trout habitat monitoring will commence after the Bridgewater Powerhouse has been replaced with either a new powerhouse or valve system and compliance operations have begun. This measurement and evaluation will continue through the next cycle of NCDWQ Catawba River Basinwide Assessment period, but not beyond Year 2019. Results of this monitoring are not intended to be used for water quality certification compliance purposes, but for continued aquatic resource assessments. These monitoring results may be used to determine if flow reductions need to be made in the Catawba River Bypassed Reach.

#### Sensor Locations

The temperature and level logger placement is designed to be able to record temperatures, flow (level logger with stage-discharge relationship) from the inflows, and empirically determine the temperatures at the appropriate downstream river reaches. An additional temperature and level logger will be provided at the Watermill Bridge (RM 271.7) in Glen Alpine, NC which is in the middle of the primary trout habitat.

**Bridgewater Supplemental Trout Habitat Monitoring****System Requirements**

Level loggers (devices to record river stage from which a stage-discharge relationship may be developed to calculate flow) and temperature loggers will be placed in the river and periodically downloaded to obtain the respective data. Stage-discharge curves will be developed at the level logger sites.

**Reporting Requirements**

Annual reports will be provided to NCDWQ and NCWRC (30 April) for the duration of the supplemental trout habitat monitoring detailing the previous calendar year's temperatures and levels. Flow-weighted temperatures will be calculated for the downstream sites.

**APPENDIX B**  
**TURBINE AERATION ASSESSMENT FOR WYLIE HYDRO – 2002**

# TURBINE AERATION ASSESSMENT FOR WYLIE HYDRO—2002



Prepared by

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**PRINCIPIA RESEARCH CORPORATION**

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# **TURBINE AERATION ASSESSMENT FOR WYLIE HYDRO--2002**

## **INTRODUCTION**

An assessment of alternatives to provide aeration and minimum flow for Wylie tailwater indicated that turbine venting would probably be the most cost-effective management approach for increasing dissolved oxygen in the hydropower discharges from Wylie, subject to additional site evaluations. A project to further evaluate this alternative was developed by Duke Power. The objectives of this project were to

1. Determine dissolved oxygen (DO) uptake and effects of existing turbine venting modifications on power production efficiency of units 2 & 3;
2. Determine the potential for turbine venting on units 1 & 4 and for increasing the capability of turbine venting on units 2 & 3;

This report presents the results of field studies and analyses that address these two objectives.

Based on the aeration assessment prepared on Wylie Hydro in January 2002, it was determined that DO improvement in the Wylie tailwater using turbine venting would be a result of aeration within the turbines themselves and also a result of withdrawal zone expansion within the lake. Turbine aeration involves the addition of DO to the water passing through the turbines by allowing air to be aspirated into the turbine system. This air is introduced immediately below the turbine wheel where a vacuum occurs for units having characteristics similar to those at Wylie. Withdrawal zone expansion involves the withdrawal of water from the surface layer of the lake where DO is usually relatively high due to contact with the atmosphere as well as due to algal production of DO.

The remainder of this report is organized as follows:

1. DO improvements attributed to turbine aeration, i.e., not including the effects of withdrawal zone expansion,
2. DO improvements attributed to withdrawal zone expansion,
3. Conclusions, and
4. Recommendations

## **TURBINE AERATION TESTS**

The power generating facility at Wylie Dam is composed of four hydroturbine-generator units. Figure 1 shows the powerhouse and the discharge area of the four units. The turbines are of the Francis type and are positioned such that under discharge conditions, the centerline of the runners is well above the elevation of the tailwater. This configuration suggests that turbine venting is a viable option for increasing the dissolved

oxygen concentration (DO) in the turbine discharge. Each of the Units is equipped with a 4-inch diameter and a 6-inch diameter vacuum breaker pipe through which air can be induced into the turbine. Units 2 and 3, which are identical, have both been modified to induce additional air by adding a 10-inch diameter air supply pipe and a 6-inch diameter pipe through the Unit headcover. Both of these Units have been equipped with air valves to control the induced airflow, but the valves on Unit 2 are not yet automated. Unit 1 is similar in geometry to Units 2 and 3, but has not been modified to allow induce additional air into the turbine. Unit 4 has different geometry than the other three units. Some of the important differences in the 4 units are given in Table 1. To measure the effects of the modifications made to Unit 3, and to evaluate the potential for turbine venting on Units 1 and 4, tests were conducted on these three Units July 23-26, 2002. This report describes the tests and presents the results obtained. Since Units 2 and 3 are identical and the air valves on unit 2 had not yet been automated, no tests were run on Unit 2, and it was assumed that the results from Unit 3 would apply to Unit 2.



**Figure 1: Wylie Powerhouse and Discharge Area**

<b>Unit</b>	<b>Vacuum Breaker Pipes</b>	<b>Additional Aeration Pipes</b>	<b>Air Valves</b>	<b>Existing Turbine Manufacturer</b>
<b>1</b>	<b>6-inch &amp; 4-inch</b>	<b>None</b>	<b>NA</b>	<b>Alstom</b>
<b>2</b>	<b>6-inch &amp; 4-inch</b>	<b>6-inch &amp; 10-inch</b>	<b>Automated</b>	<b>Alstom</b>
<b>3</b>	<b>6-inch &amp; 4-inch</b>	<b>6-inch &amp; 10-inch</b>	<b>Manual</b>	<b>Alstom</b>
<b>4</b>	<b>6-inch &amp; 4-inch</b>	<b>None</b>	<b>NA</b>	<b>American Hydro</b>

**Table 1— Differences in Turbine Units that affect Aeration Effectiveness**

## **Test Description**

The tests were conducted jointly by Reservoir Environmental Management Inc. and Duke Power. The objectives of the tests were to

- Measure the amount of air induced for different turbine operating conditions.
- Measure the dissolved oxygen (DO) uptake obtained from the air induction.
- Determine the effect of the air induction on unit efficiency and power output.
- Determine the effects of aeration on DO, total dissolved gas, and temperature in the tailrace.

Units 1, 4 and 3 were each instrumented and tested separately on July 23, 24, and 25, respectively; and, then on July 26, Unit 3 was tested during multi-unit operation.

## **Instrumentation and Procedures**

Most of the instruments used for airflow and turbine efficiency measurements for these tests were temporarily installed by Principia Research Corporation for REMI with the assistance of Duke personnel. These included instruments for determination of inlet pressure, relative water flow rate, airflow rate, wicket gate servomotor stroke, and water temperature. Existing, permanently installed instruments were used for the measurement of headwater elevation, tailwater elevation, and power output. A summary of the transducers used is presented in Table 2. Instrumentation specifications for the PRC-supplied instruments are found in Appendix A. Calibrations for these instruments are found in Appendix B.

Temperature, dissolved oxygen concentration (DO) and total dissolved gas concentration (TDG) measurements used for the turbine venting tests were taken using a boat mounted Hydrolab DataSonde®. The boat was maneuvered in the tailrace so as to obtain measurements representative of the discharge of the turbine unit being tested

With the exception of the DO, TDG, and temperature readings, test data were acquired with a Hewlett-Packard 34970A data acquisition system controlled by HP's Benchlink software. As indicated in Table 2, most of the instruments employed 4 – 20 mA current loop outputs. 250-ohm precision resistors were used to convert the current loops to 1 – 5 V for input to the data acquisition system. The data acquisition system and control computer were located on the generator floor near the SCADA cabinets, allowing for easy access to the SCADA instrument loops. All transducer outputs were wired to the data acquisition system. During most test runs data were recorded for three minutes for three minutes, with all channels being recorded every one second.

**Table 2****Instrumentation for Turbine and Airflow Measurements**

Chan	Parameter	Symbol	Units	Method	Instrument	Signal
1	Water flow primary <sup>(1)</sup>	$h_P$	in H <sub>2</sub> O	Scrollcase differential	Rosemount 3051C DP cell	4-20 mA
2	Water flow secondary <sup>(1)</sup>	$h_S$	in H <sub>2</sub> O	Scrollcase differential	ABB 624T DP Cell	4-20 mA
3	Air flow 4"	$h_4$	in H <sub>2</sub> O	Bellmouth inlet	Rosemount 3051C DP cell	4-20 mA
4	Air flow 6"	$h_6$	in H <sub>2</sub> O	Bellmouth inlet	ABB 624T DP Cell	4-20 mA
5	Air flow 10"	$h_{10}$	in H <sub>2</sub> O	Bellmouth inlet	Rosemount 3051C DP cell	4-20 mA
6	Inlet pressure	$h_I$	ft H <sub>2</sub> O	Inlet gate slot water surface elevation	Rosemount 3051C DP cell	4-20 mA
7	Headcover pressure	$H_{HC}$	ft H <sub>2</sub> O	Pressure tap at base of 4" air line	Rosemount 3051C DP cell	4-20 mA
8	Barometric pressure	$P_{atm}$	psia	Barometric cell in wheel pit	Rosemount 3051C AP cell	4-20 mA
9	Gate position - PRC	$G_1$	%	Servo stroke	Celeco PT420-0040 Pull Pot	4-20 mA
10	Gate position - Plant	$G_2$	%	Servo stroke	Internal LVDT	4-20 mA
11	HW elevation <sup>(2)</sup>	$HW$	ft	Plant float and transmitter	Float/stilling well	0 - 1 mA
12	TW elevation <sup>(3)</sup>	$TW$	ft	Plant float and transmitter	Float/stilling well	0 - 1 mA
13	Power	$P$	MW	Plant wattmeter	Plant wattmeter	0 - 1 mA
14	Water Temp	$T_W$	deg F	RTD in raw water bleed	Dwyer 3-wire temp. transmitter	4-20 mA
15	Air Temp	$T_A$	deg F	RTD in wheelpit	Omega HX-70 transmitter	4-20 mA
16	RH	$RH$	%	RH sensor in wheelpit	Omega HX-70 transmitter	4-20 mA

Notes:

1. "Primary flow" used idle unit as high side pressure. "Secondary" uses inlet gate slot water surface as high side.

2. For data analysis, the inlet head was used for headwater elevation.

3. For data analysis, data retrieved from Duke's submersible level logger was used

### **Airflow**

Airflows were determined by measuring the pressure drop at the entrance to bellmouth inlets installed in place of the muffler/screen normally used at the air admission intakes. These bellmouths were fabricated from PVC spoolpiece sections, with one flange used to connect to the piping, and the other flange rounded on the inside to form a smooth entrance section for the airflow. Two diametrical pressure taps were installed about one pipe diameter downstream of the inlet, and were connected in a tee arrangement. These bellmouths were fabricated in 4-, 6-, and 10-inch diameters, matching the air supply piping sizes. On Units 1 and 4, only the 4 and 6-inch bellmouths were used. Unit 3 has an additional 10-inch air intake. Photographs of these bellmouths are shown in Figures 2, 3 & 4.

Pressure readings were made using Rosemount pressure cells, with the low port connected to the intake port tee, and the high side left open to the atmosphere.

### **Water Flow**

The units at Wylie have no Winter-Kennedy taps for relative flow measurement. Following previous practice, a water-flow-related differential pressure was obtained from a tap located on the scroll case mandoor of the operating unit and a similar tap on an adjacent non-operating unit. In this case, the pressure at the non-operating unit was equivalent to the headwater elevation.

In an effort to eliminate the influence of trashrack losses on this measurement, a water-filled Tygon tubing line was run from the intake gate slot to the turbine floor to provide the high-side pressure to an additional pressure cell which was also connected to the scroll case tap.

Pressure differentials were measured with Rosemount 3051C and ABB 624T differential pressure transducers.

### **Headwater Elevation**

Headwater elevation was determined from the pressure at the intake tube described above, corrected for the turbine floor elevation. This measurement eliminates the effect of trashrack losses on the net head determination.

The plant headwater gage was also monitored for these tests.

### **Tailwater Elevation**

The plant tailwater gage was to be the primary tailwater elevation measurement. However, near the end of the test program, it was determined that this gage was not responding properly. Tailwater measurements from the tests were subsequently determined from a Duke-supplied submersible level logger, which had been put in the Unit 1 side of the tailrace at the start of testing.

### **Wicket Gate Position**

The wicket gate servo stroke was measured using a Celesco cable extension transducer (“pull-pot”) mounted on one of the servos of the tested units. The transducer was

attached to a mounting bracket, which was clamped to a member of the wicket gate linkage. The free end of the cable was attached to a bracket on the servo cylinder housing. The cable was installed so that it was level and parallel to the axis of motion. The stroke between the unit off and at full gate opening was defined as 100% stroke.

#### **Air Pressure, Temperature, and Relative Humidity**

Air pressure was measured in the wheel pit using a Rosemount model 3051C absolute pressure cell. Temperature and relative humidity were measured in the wheel pit using an Omega Engineering model HX-93 Temp/RH transmitter.

#### **Headcover Pressure**

It was not feasible to obtain a direct headcover pressure measurement. Instead, a pressure tap was installed the base of the 4-inch air admission line, and this pressure was measured using a Rosemount 3051C pressure transmitter.

#### **Power Output**

Power output was recorded from the plant SCADA system instrument loop.

#### **Water Temperature**

Water temperature was measured using a Dwyer 3-wire RTD transmitter immersed in water continuously drawn from a raw water supply line on the turbine floor.

The discharge DO and temperature readings were recorded in separate files integral to the monitors used to collect the data.



**Figure 2: 4-inch Bellmouth Flow Measuring Device**



**Figure 3: 6-inch Bellmouth Flow Measuring Device**



**Figure 4: 10-inch Bellmouth Flow Measuring Device**

Dissolved oxygen, TDG (total dissolved gas) and temperature measurements were made using Hydrolab® multiprobe water quality monitors. The monitor currently used to measure DO in the tailrace is mounted on the restraining wall near the discharge from Unit 1. This monitor was considered to be inadequate for measuring DO in the discharge from each unit, so additional monitors were used at selected areas of the tailrace and an additional monitor was operated from a boat, which for each test run was maneuvered into an area, which appeared to be representative of the discharge from the unit being tested. A photograph of the boat in position for data collection for one of the test run on Unit 3 is shown in Figure 5. A review of the collected data and observations made of flow patterns in the tailrace indicated that the measurements made from the boat were the most reliable and it was these measurements which were used to calculate DO uptake and oxygenation efficiency



**Figure 5: Boat in Position for Tailrace DO Measurements**

The instrumentation was installed and checked before testing was initiated. Calibrations, especially on the bellmouth differential pressure cell were done before each set of tests and when conditions prompted recalibration. The Hydrolab monitors deployed in the river were pre- and post-calibrated, and the Hydrolab monitor used in the boat was also calibrated on July 24 and July 25.

The test procedure was to establish a desired wicket gate position and wait for conditions to stabilize before recording data. The variable which usually determined test condition stability was tailrace DO as measured from the boat. Each test run usually took about 10 to 15 minutes for conditions to stabilize and data to be recorded.

## **Data Reduction Procedures For Turbine and Airflow Measurements**

### **Air Flow**

Air flow into a bellmouth inlet calculated from the standard compressible flow equation as given in ASME's *Fluid Meters*:

$$Q_A = 0.099702 \left( \frac{C \cdot Y \cdot d^2 \cdot F_a}{\sqrt{1 - \beta^4}} \right) \sqrt{\frac{h_A}{\rho_A}}$$

where

$Q_A$  = air flow (scfs)

$C$  = inlet nozzle coefficient  $\cong 0.99$

$Y$  = gas expansion factor (computed from formula, but  $\cong 1.0$ )

$D$  = inside diameter of bellmouth spoolpiece (in)

$F_a$  = thermal expansion factor  $\cong 1.0$

$H_A$  = pressure differential for given flow nozzle (in H<sub>2</sub>O)

$\rho_A$  = air density in wheel pit (computed from air density equation) (lbm/ft<sup>3</sup>)

### **Water Flow**

Water flow through a turbine was estimated from the scroll case differential pressure by the following equation:

$$Q_W = C \sqrt{h_W}$$

where

$Q_W$  = water flow rate (cfs)

$C$  = flowmeter coefficient (= 707)

$h_W$  = measured head difference across the flowmeter taps (in H<sub>2</sub>O)

Based on previous test results, the coefficients  $C$  were chosen to yield a peak efficiency for each unit of about 95%.

### **Turbine Net Head**

Turbine net head is computed as follows

Inlet static head,  $h_{IS}$ :

$$h_{IS} = h_I + Z_I$$

where:

$h_I$  = inlet static head measured at pressure cell elevation (ft H<sub>2</sub>O)

$Z_I$  = elevation of pressure cell (= 525 ft)

Inlet velocity head,  $H_{VI}$ :

$$H_{VI} = \frac{1}{2g} \left( \frac{Q_W}{A_I} \right)^2$$

where

$Q_W$  = water flow rate (cfs)

$A_I$  = intake area ( = 705ft<sup>2</sup>)

$g$  = acceleration of gravity ( = 32.14 ft/s<sup>2</sup>)

Inlet total head,  $H_I$ :

$$H_I = h_{IS} + H_{VI}$$

Discharge static head,  $h_d$ :

$$h_d = H_{TW}$$

where

$H_{TW}$  = tailwater elevation (ft)

Discharge velocity head,  $H_{VD}$ :

$$H_{VD} = \frac{1}{2g} \left( \frac{Q_W}{A_D} \right)^2$$

$A_d$  = area at the draft tube opening to the tailrace ( = 525.4 ft<sup>2</sup>)

Discharge total head,  $H_D$ :

$$H_D = h_D + H_{VD}$$

Turbine net head at test conditions,  $H_T$ :

$$H_T = H_I - H_D$$

### **Turbine Efficiency**

Turbine efficiency,  $\eta$  is computed from

$$\eta = 737.6 \frac{P_T}{\rho g Q_W H_T}$$

where turbine power  $P_T$  is given in kilowatts, and other terms have been defined previously.

### **Correction of Efficiency Test Results to Common Head**

#### **Turbine Mode**

The measured flow rate and turbine power output at the test head is corrected to a common head,  $H_c$ , by:

$$Q = Q_T \left( \frac{H_c}{H_T} \right)^{0.5}$$

$$P = P_T \left( \frac{H_c}{H_T} \right)^{1.5}$$

No correction is required for efficiency.

Test results were corrected to a common head of 72 feet for all tests.

### **Tabular Summaries**

Tabular summaries of the data collected and computations are given in Appendix C. Graphical interpretations of these data are given elsewhere in this report.

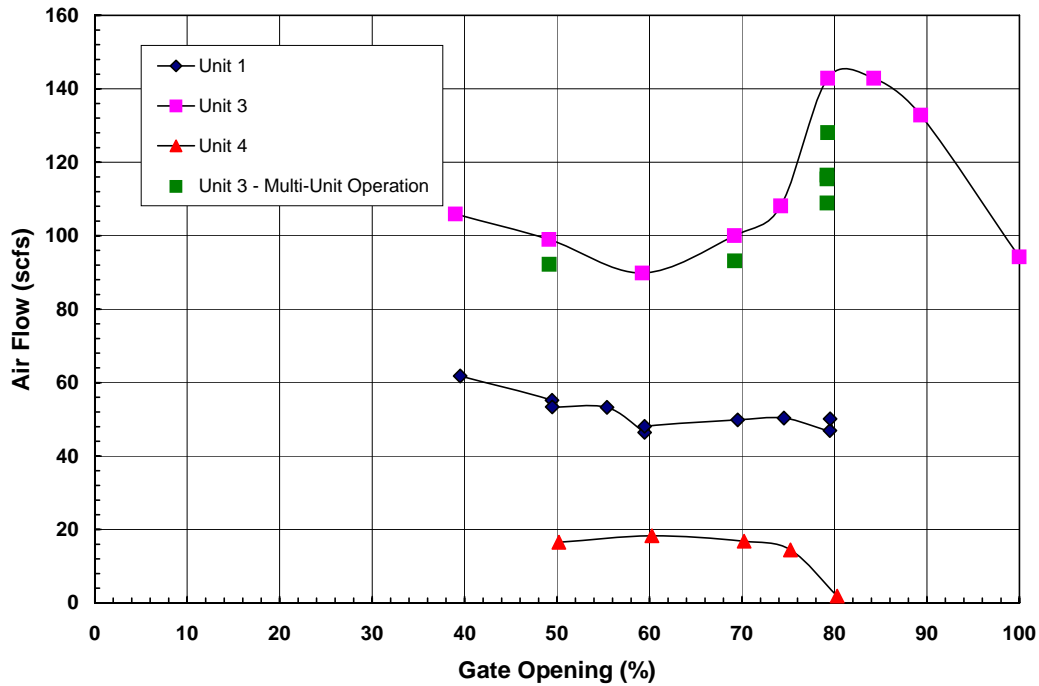
## **Results**

Summary tables of the data used for the graphical presentations of turbine venting results in the report are provided in Appendix D. The values shown in the tables are the averages of the recorded data for the test runs. A review of the DO and water temperature data indicated that the data collected from the boat in the tailrace were the most representative, therefore these data were used to calculate oxygenation efficiencies and DO uptake.

### **Induced Air Flow**

Induced airflow measured for each of the three units tested is shown on Figure 6 as a function of wicket gate opening. These data indicate that:

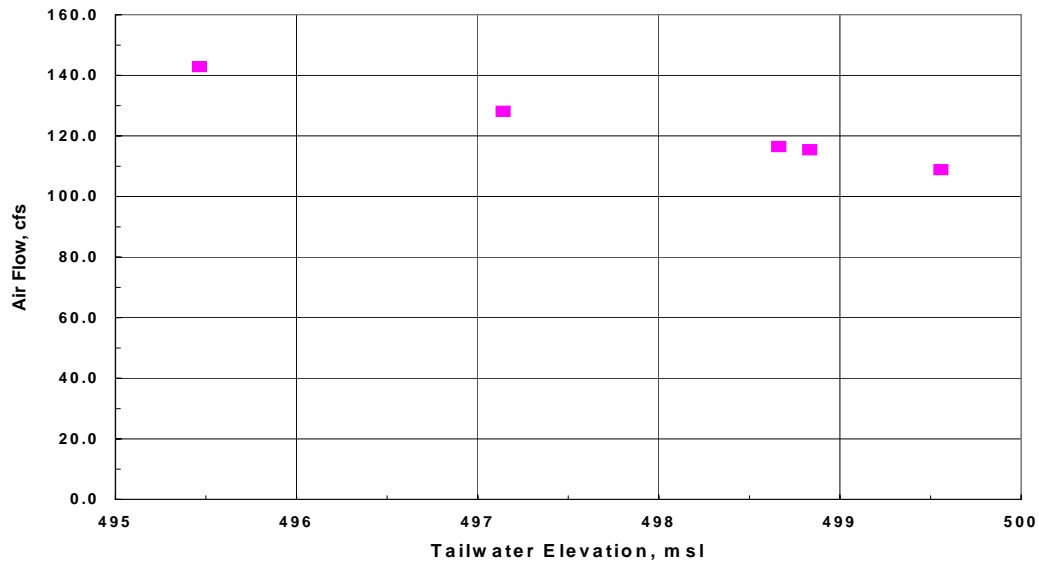
1. 90 to 142 scfs of air was induced into the modified unit (Unit 3), as compared to 50-60 scfs on the un-modified similar unit (Unit 1)
2. The maximum amount of air was induced into Unit 3 at best gate operation (near 80 percent wicket gate opening),
3. The amount of air induced into Unit 1 decreased slightly as gate opening increased.
4. Less than 20 scfs of air was induced into Unit 4, and air flow stopped entirely at 80 percent wicket gate opening



**Figure 6: Effect of Wicket Gate Opening on Air Flow**

### Tailwater Elevation Effect

Included on Figure 6 are six data points obtained when additional units were operated along with unit 3. These data indicate that air induced into unit 3 decreased when the other units were operated. Data obtained from these multiunit tests are included on Figure 7 which shows that as tailwater increased (due to multi-unit operation) the airflow induced through unit 3 operating at 80% gate opening decreased.



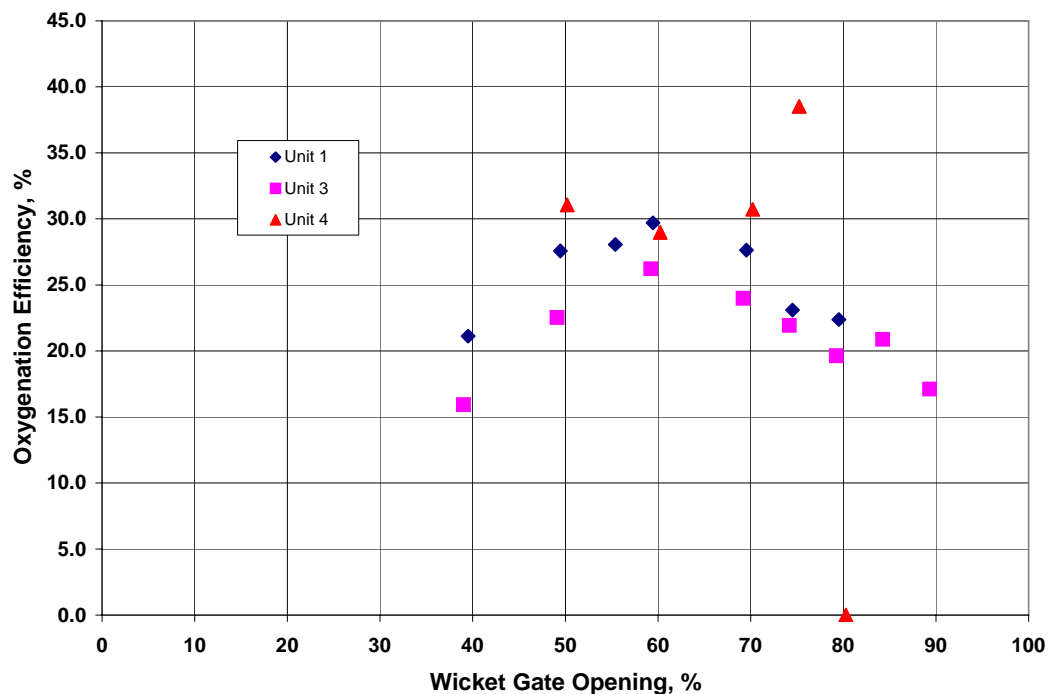
**Figure 7: Effects of Tailwater Elevation On Induced Air Flow, Unit 3 at 80% Gate**

### Oxygenation Efficiency

Oxygenation efficiency,  $E_o$  is defined as the mass of oxygen available in the induced air divided by the mass of oxygen added to the turbine discharges. To obtain the mass of oxygen that was added to the turbine discharges, the concentration of DO measured in the tailrace with and without airflow was multiplied by the water flowrate to determine the mass rate of oxygen.

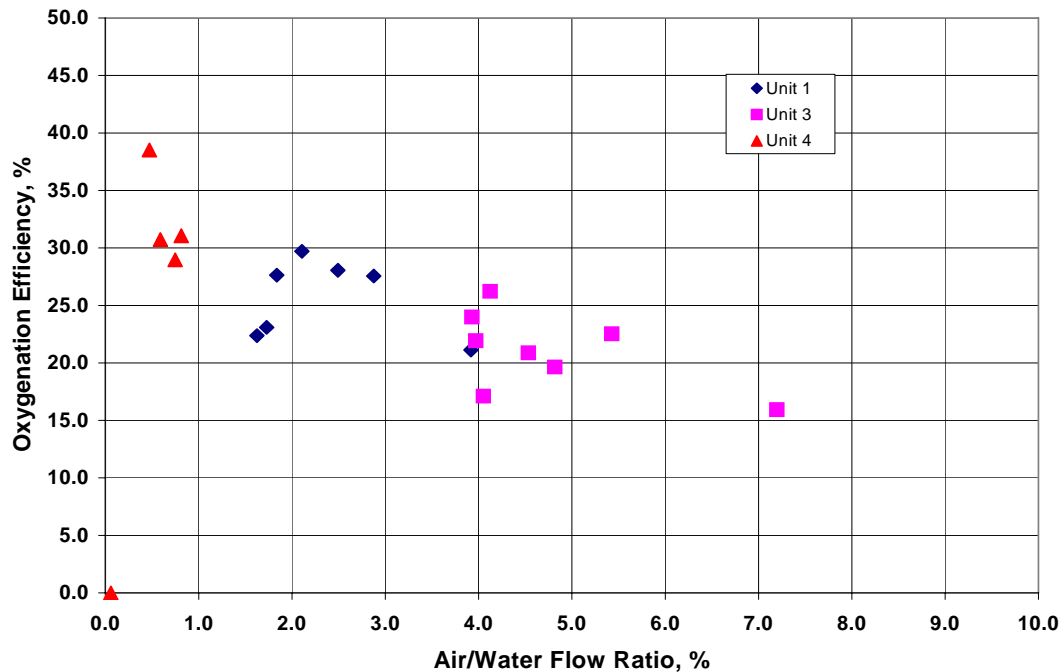
Oxygenation efficiency as a function of wicket gate opening is shown on Figure 8. Overall, the efficiency for all three units tested was about 25% and was about 20 % at 80 % wicket gate opening.

$E_o$  is a function of the following variables: the DO concentration in the draft tube, the saturation concentration for DO in the draft tube, the travel time of the air/water mixture through the draft tube, the depth of the tailrace, the pressure of the air/water mixture, the ratio of the air to water flow rates in the draft tube and the distribution of air and water in the draft tube.



**Figure 8: Oxygenation Efficiency**

The relationship between oxygenation efficiency and air/water flow ratio is shown on Figure 9. The data from all three units appear to follow a more or less linear relationship and indicate that the oxygenation efficiency was more affected by air/water ratio than by individual unit characteristics and/or geometry.



**Figure 9: Effect of Air/Water Ratio on Oxygenation Efficiency**

### Dissolved Oxygen Uptake

Dissolved oxygen increases in the turbine discharge as a function of wicket gate opening are shown on Figure 10. As might be expected, the DO uptake for unit 3 was greater than for the other two tested units, and the uptake for unit 4 was less than for the other two units. Uptake for unit 3 ranged from about 3.5 to 2.0 mg/L, for unit 1 from about 2.3 to 1.0 mg/L, and for unit 4 from about 0.7 to 0 mg/L. For all three units, DO uptake decreased with wicket gate opening.

Also included on Figure 10 are DO uptakes for unit 1 with unit 4 operating and for unit 3 with unit 1 operating. These data indicate that operating unit 4 had little effect on DO uptake for unit 1, but that in most cases, the uptake for unit 3 dropped about 1 mg/L when unit 1 was operating. This decrease may be due to a number of factors:

- The local effect of tailwater elevation on the amount of air induced
- Mixing of the discharges in the tailrace before measurements were taken
- The withdrawal zones changing in the reservoir when units near one another are operated.
- The DO in unit 3 increasing during the tests when Unit 1 was operating

Figure 11 shows the effect of air/water flow ratio on DO uptake for all three units tested. Considering the data from all three units as a continuous curve, these data indicate that the relationship was not linear, but that uptake may approach a maximum as the air/water ratio increases (i.e., for air/water ratios greater than about 5 percent, the effect of more air

does not increase the DO linearly.) This non-linear relationship could be caused by the increase in the DO concentration. Aeration rates typically follow first-order reaction kinetics that depends on the saturation concentration of DO.

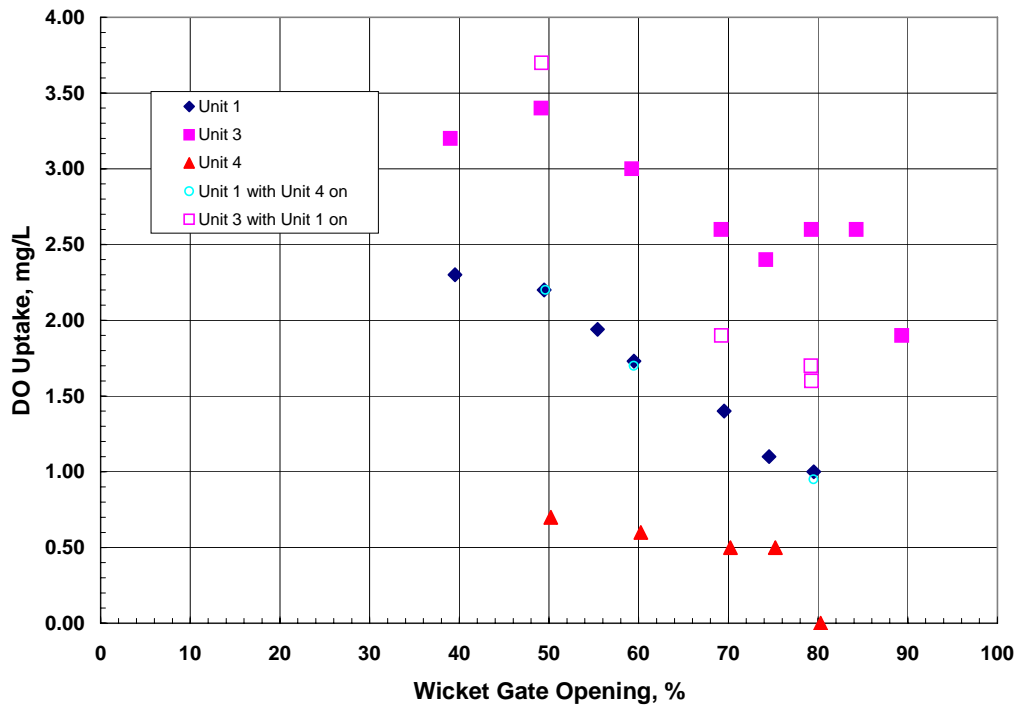


Figure 10: DO Uptake

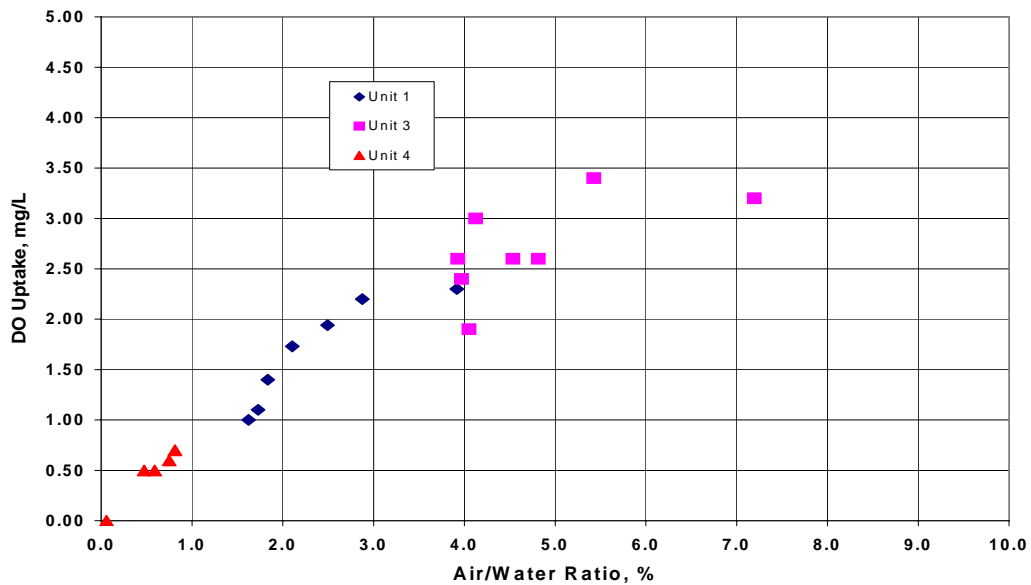
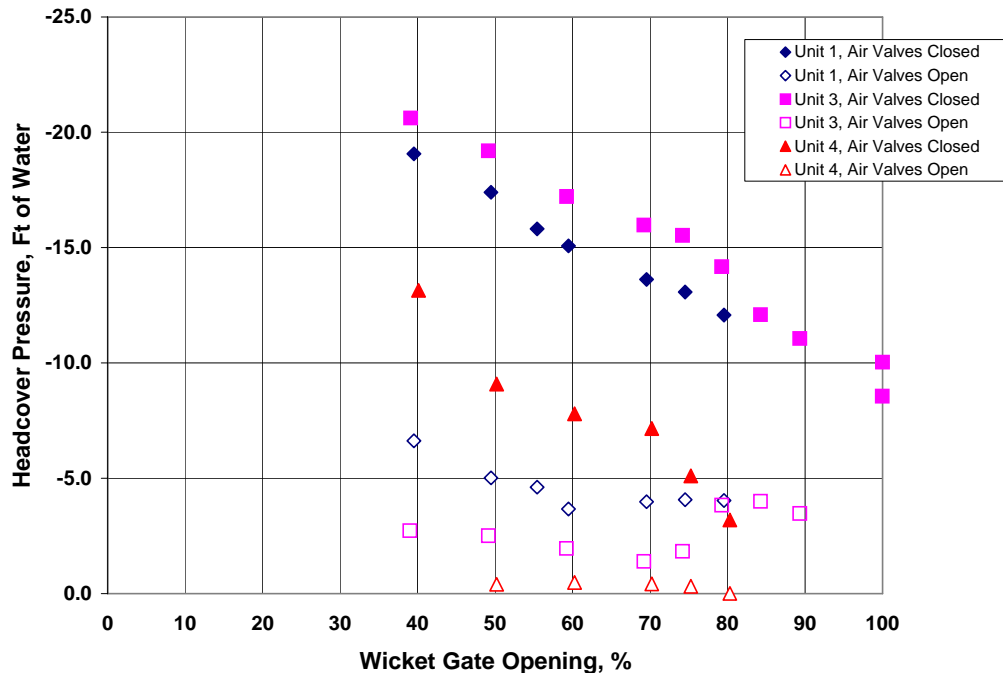


Figure 11: Relationship of Air/Water Ratio to DO Uptake

### Headcover Pressures

Figure 12 shows headcover pressures as a function of wicket gate opening measured both with and without the air valves open. Negative pressures under the headcover with the air valves open indicate that additional air could be induced if piping were installed to admit more air.

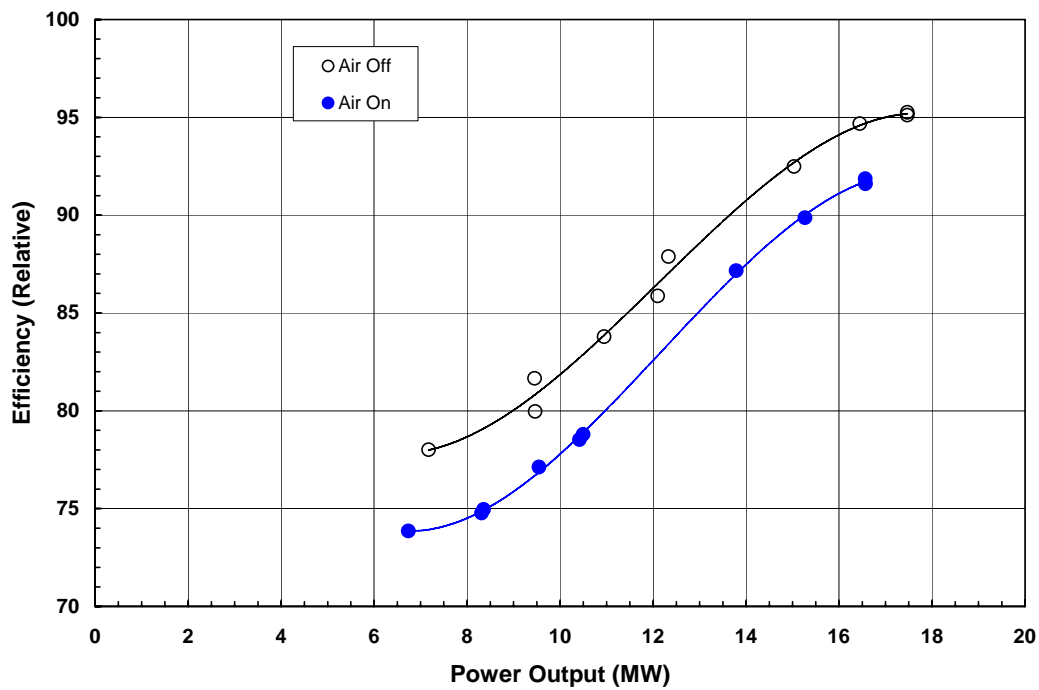
The data with the air valves open show headcover pressures of about -5 feet of water for unit 1, -2 feet of water for unit 3 and -1 feet of water for unit 4. These data indicate that potentially more air could be induced into units 1 and 3 if more air passages were installed, although the increase may not be great for unit 3. Since the data show very little negative pressures for unit 4, the installation of additional air piping would not help induce more air. It may however be possible to get more air into unit 4, by making turbine modifications such as installation of hub baffles to decrease headcover pressure.



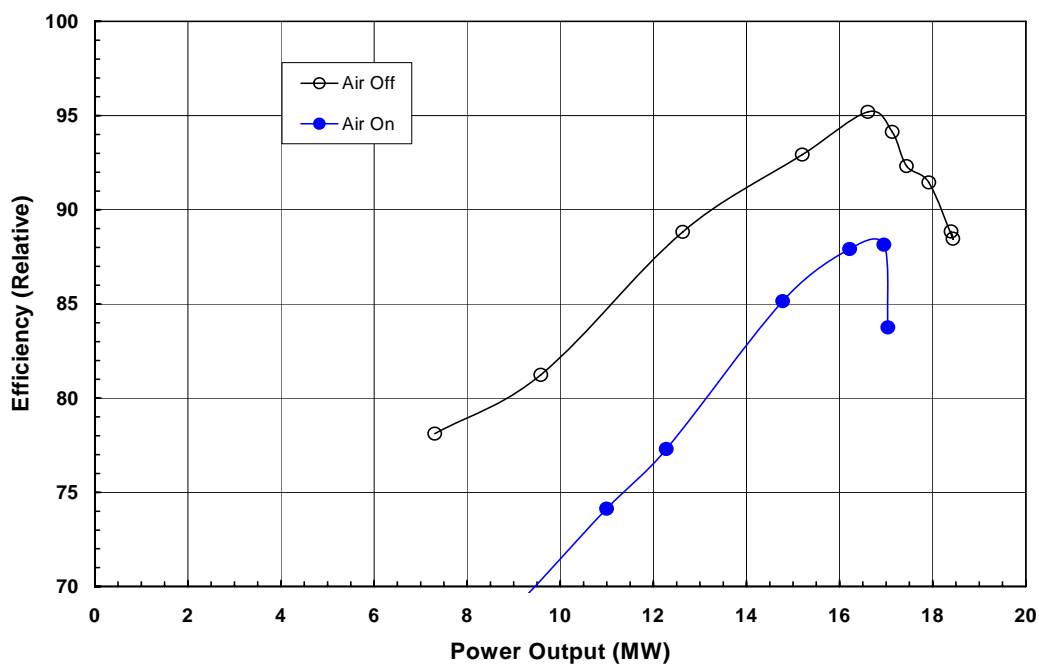
**Figure 12: Effect of Air Flow on Headcover Pressure**

### Generation Efficiency

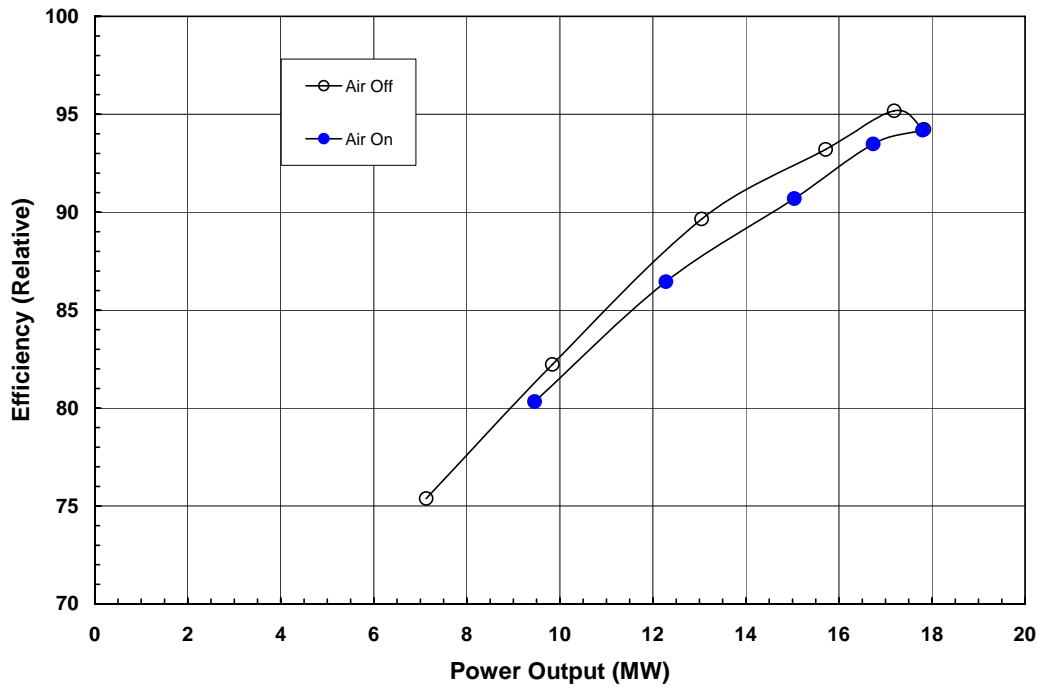
The effect of the airflow on generation efficiency can be ascertained by comparing generation efficiency with and without air induction. The data on Figures 13, 14 & 15 indicate that the induced air reduced generating efficiency by about 3-5 percent on unit 1, about 6-11 percent on unit 3 and 1-2 percent on unit 4.



**Figure 13: Effect of Air on Unit Efficiency, Unit 1**



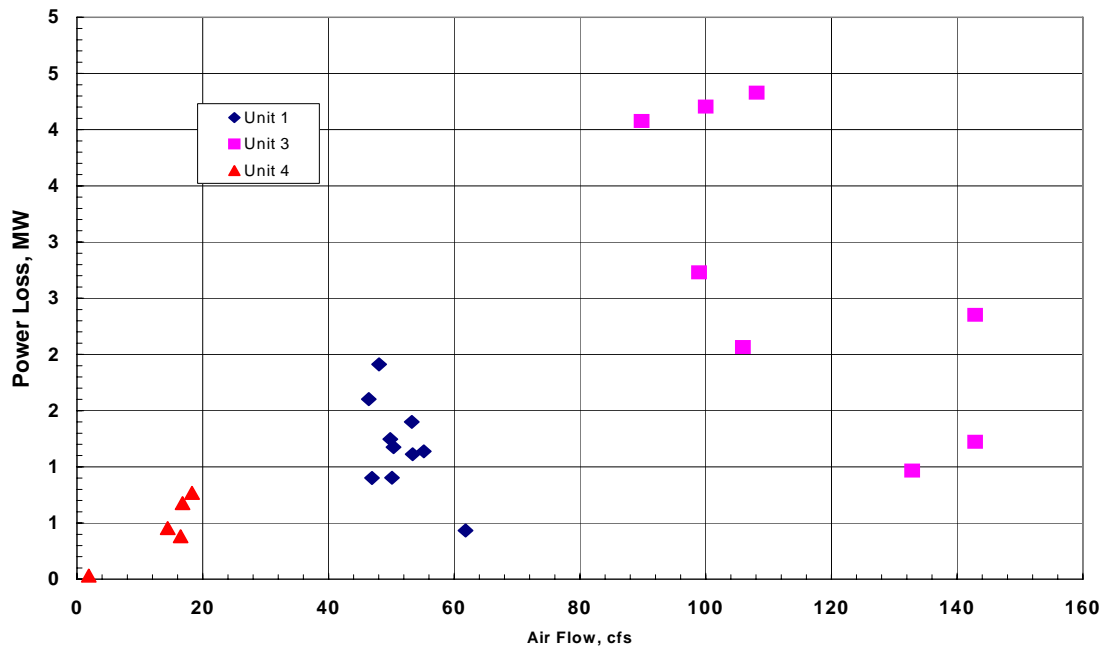
**Figure 14: Effect of Air on Unit Efficiency, Unit 3**



**Figure 15: Effect of Air on Unit Efficiency, Unit 4**

### Power Output

As shown on Figure 14, maximum power output for unit 3 (the only one tested at 100% gate) was reduced about 1.5 mw by the presence of the air.



**Figure 16: Effect of Air Flow on Power Loss**

Figure 16 shows the effect of airflow on measured power loss for the three units. There is significant scatter in the data, particularly for unit 3, but a linear relationship could be assumed which would indicate about 1 mw loss for every 40 cfs of air induced.

### **Effect of Air Valves**

Table 3 shows data from special tests when various combinations of air valves were operated on Unit 3. During these tests, Units 3, 1 and 4 were all operating at 80% wicket gate opening and the tailwater elevation was at about 498.9. These data indicate that most of the air was going through the 10-inch valve. Since a significant part of the noise associated with the air induction appeared to come from the operation of the smaller valves, it could be possible to reduce noise levels somewhat without significantly affecting airflow by closing the 4 and 6-inch valves. The data collected were not sufficient to determine if power output was affected by the use of different air valves.

Air Valves Open	Air Flow (cfs)	Power Output (MW)
10-inch, 6-inch & 4-inch	97	15.7
4-inch & 6-inch	54.6	16.7
10-inch	93.1	15.2
6-inch	31	17.2
4-inch	28.4	17.2

**Table 3: Effect of Unit 3 Air Valve Operation on Air Flow and Power**

### **Turbine Aeration Conclusions**

The following conclusions only address the results of the turbine aeration tests for each unit. It should be noted that aeration considerations for the whole plant should take into account the effects of all the units for the plant as well as the results of withdrawal zone expansion as discussed in the next section.

#### **Unit 1**

- There was sufficient negative headcover pressure to induce more air if air supply piping is added.
- Turbine modifications, for example the addition of hub baffles, could increase suction—consideration should be given to adding hub baffles to reduce the effects of increased tailwater elevation when multiple units are operated.

#### **Unit 3**

- Significant amounts of air, enough to increase the DO in the tailrace by as much as 3.5 mg/l, was induced into Unit 3.
- This increase in DO came at a cost of 5-6 % loss in unit efficiency.
- Induced air reduced maximum power output by about 1.5 mw when the unit was operated near 80% wicket gate opening.

- Tailwater elevation increases caused by operating additional units reduced airflow.
- The effect of introducing additional air may not result in significantly raising tailrace DO, but could significantly affect power efficiency losses.

#### **Unit 4**

- Very little air was induced into Unit 4.
- The data indicate that there is not sufficient suction under the headcover to induce air without turbine modifications.

A summary of the general conclusions is presented in Table 4.

Unit No.	Amount of Air Flow Induced	Amount of DO added at 80 % gate, mg/L	TW Elevation (Multi-unit operation) Effects On Air Flow	Would Modification Potentially Increase Air Flow?	Would Additional Air Pipes Increase Air Flow?	Power Losses Presently Caused by Air Flow
1	Moderate	1.0	Significant	Yes	Probably	Moderate
3,2	Significant	2.6	Significant	Marginal	No	Significant
4	Very Small	0	Unknown	Yes	Not without modification	Small

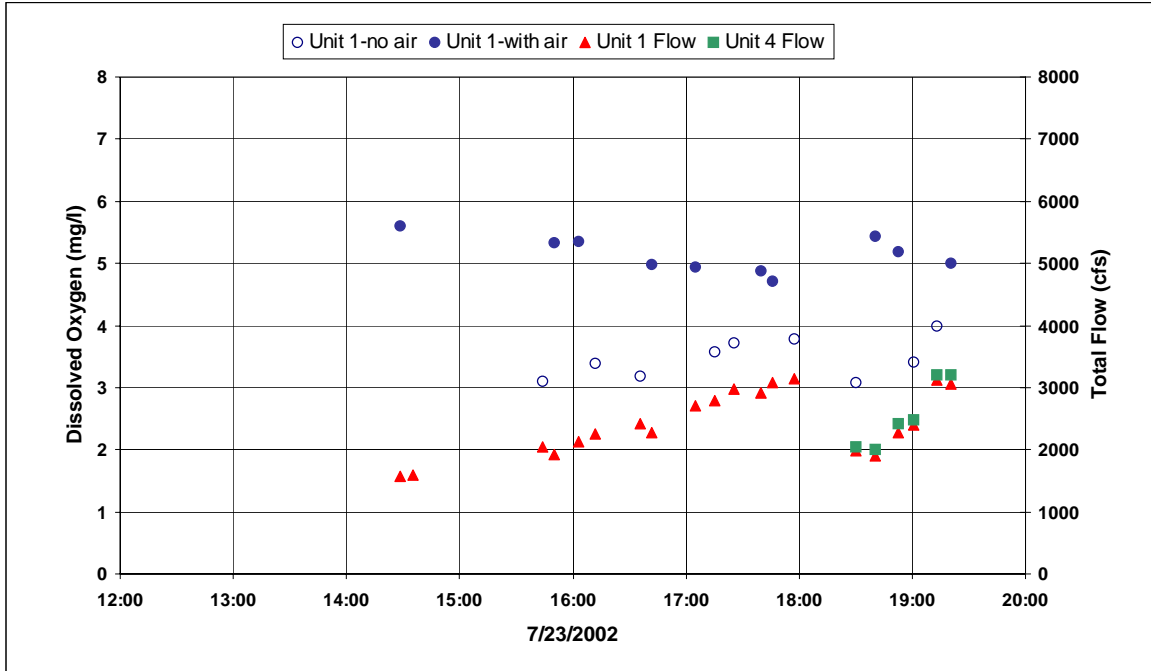
**Table 4: Summary of Turbine Aeration Conclusions**

### **WITHDRAWAL ZONE EFFECTS**

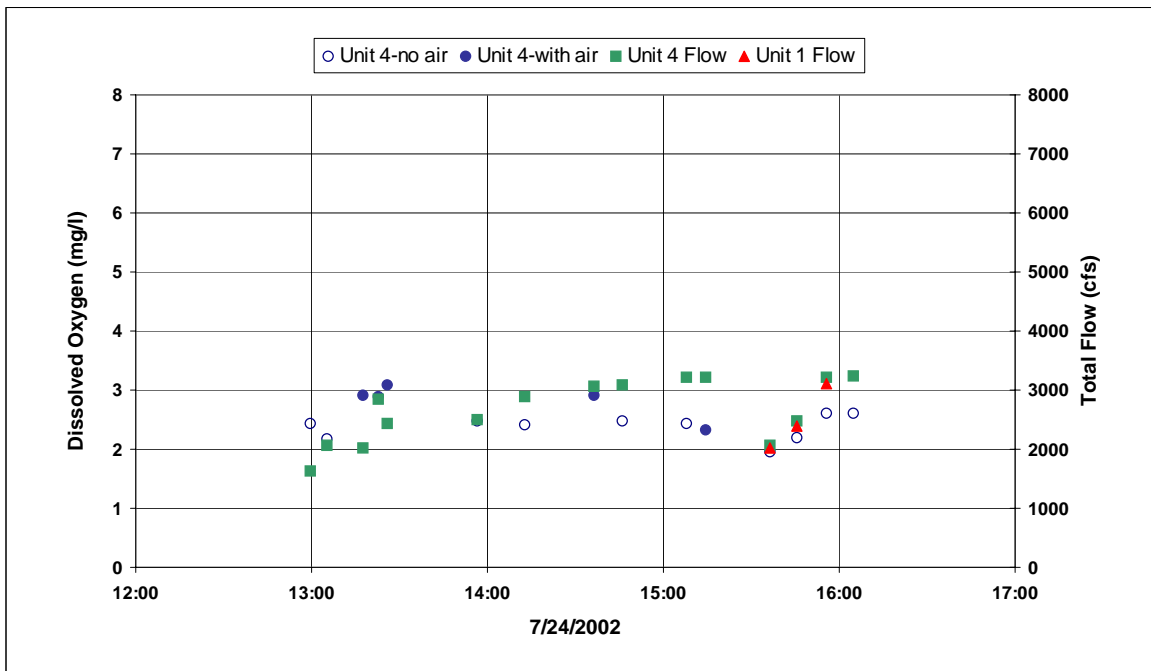
The previous section presented the results of turbine aeration on DO uptake attributed only to the effects of absorption of air that was drawn into the turbine. This section presents the effects of withdrawal zone expansion from within the lake on the DO increase in the tailwater as well as the overall DO increase in the tailwater that can be attributed to both of these factors.

Figures 17 through 20 present the results of DO measurements in the tailrace during the tests discussed in the previous section. It is important to note that the DO measured in the tailrace during the tests on Units 1 and 3 were generally equal to or greater than 5 mg/L (see Figures 17 and 19.) Figure 20 presents the results of the tests on July 26 when three and four units were operated, and these results showed that DO in the tailrace averaged about 6 mg/L when Units 1,2,3 were operated. These results also showed that even though Unit 4 drew little air, the DO in the tailrace was about 5.5 mg/L when Unit 4 was operated with Units 1,3 and Units 1,2,3. These DO values are considerably greater than the DO uptake measurements that were attributed to turbine aeration alone, e.g., the DO uptake values attributed to aeration in the discharges from Units 1 and 3 were about 1 and 2.5 mg/L, respectively, when the gate settings were about 80 percent (see Figure 10.)

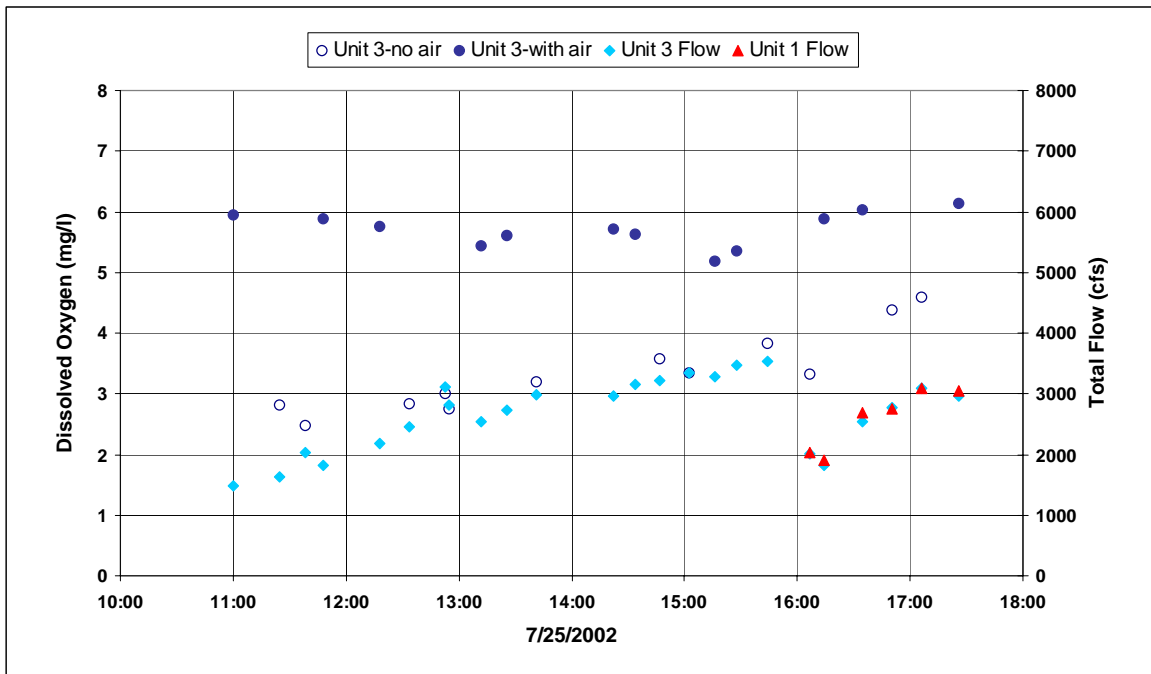
The results of the tests from the individual units are summarized in one plot on Figure 21.



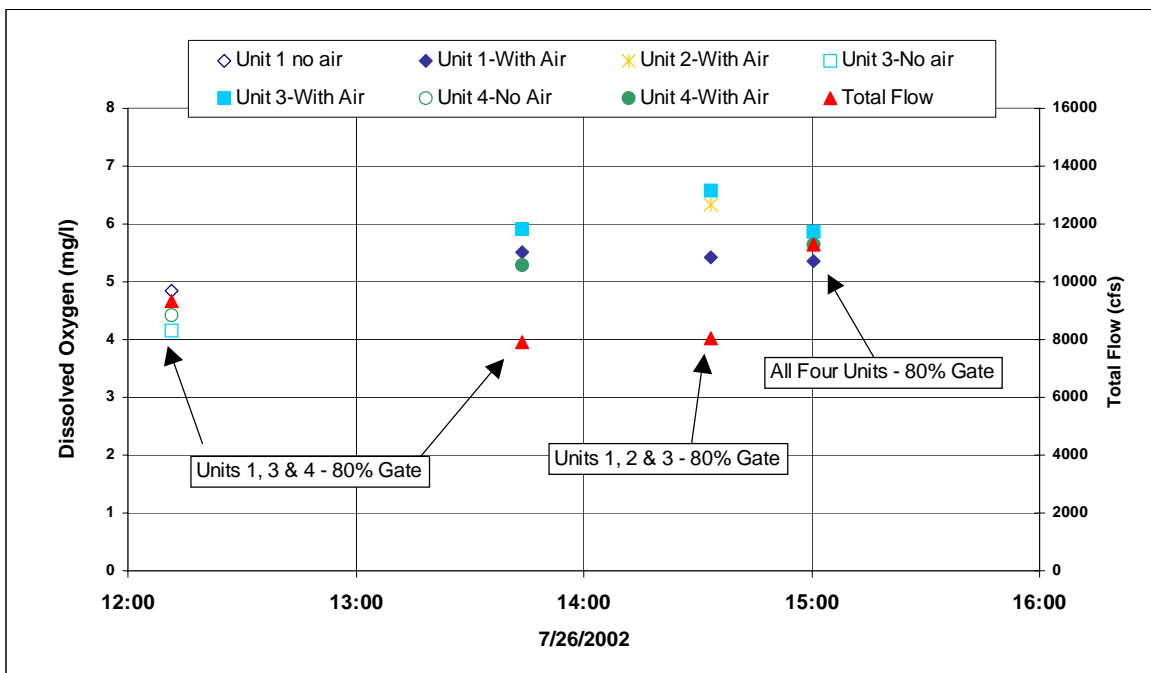
**Figure 17: Tailrace Dissolved Oxygen Measurements During Generation—7/23/02**



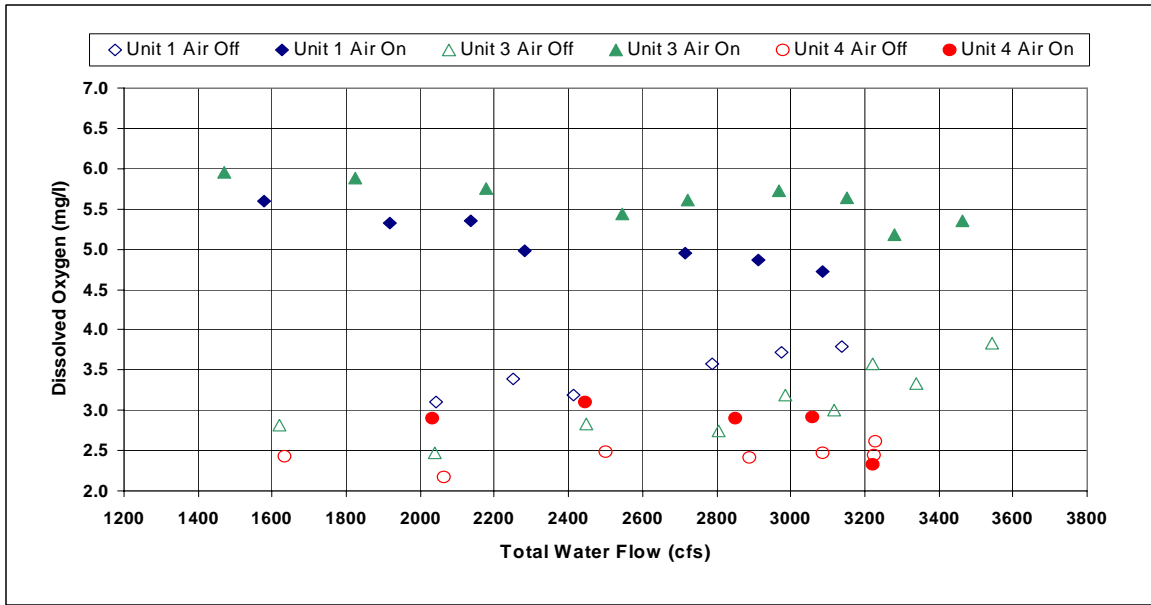
**Figure 18: Tailrace Dissolved Oxygen Measurements During Generation—7/24/02**



**Figure 19: Tailrace Dissolved Oxygen Measurements During Generation—7/25/02**



**Figure 20: Tailrace Dissolved Oxygen Measurements During Generation—7/26/02**



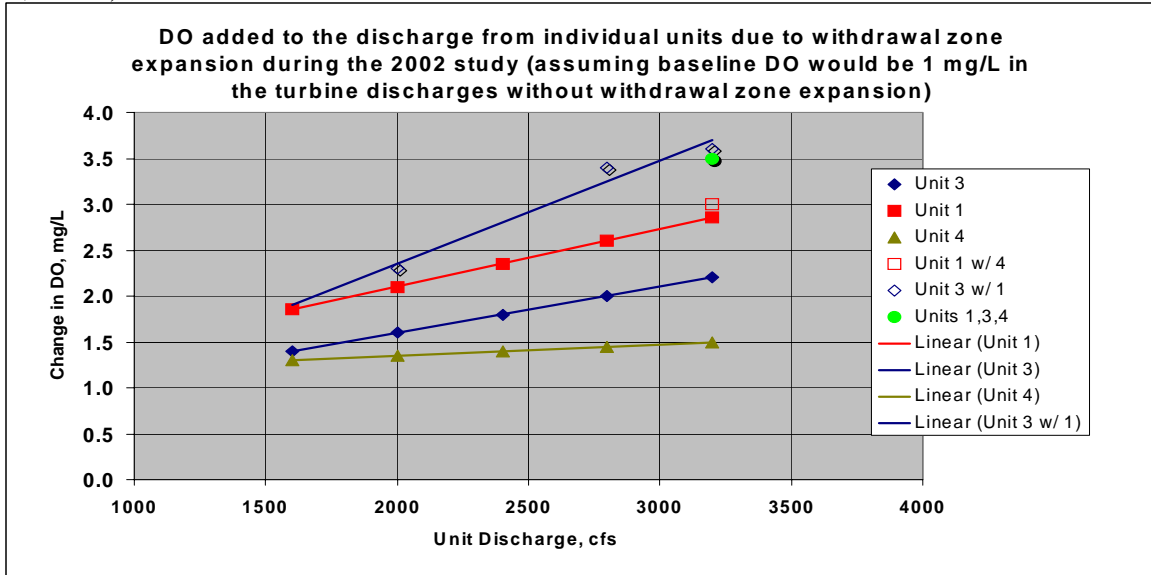
**Figure 21:Effect of Flow on Tailrace DO for All Units During Generation**

It is also important to note that the DO in the tailrace during tests when air was not admitted to the units varied significantly between the units, e.g., at 80 percent gate the DO in the tailrace of Unit 1 was 3.8 mg/L, for Unit 3 it was 3.2 mg/L, for Unit 4 it was 2.5 mg/L, and for Units 1,3,4 it was about 4.5 mg/L. These results show that the withdrawal zone expansion varies between units and increases as the total flow through the project increases.

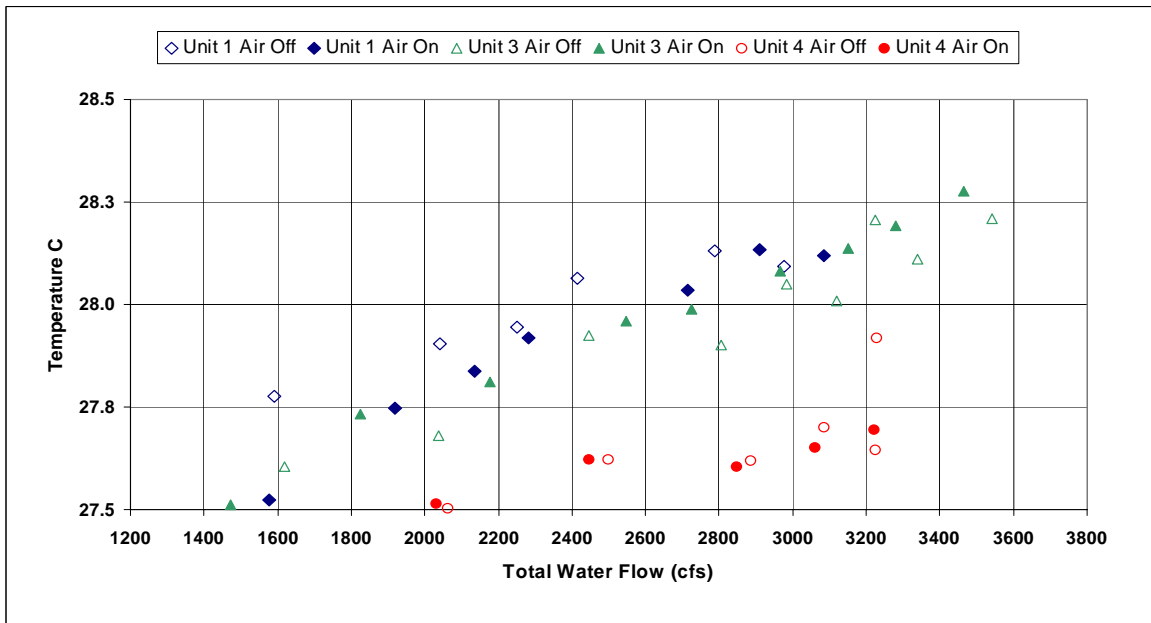
Figure 22 shows the estimated amount of DO increase in the discharges from the various units that can be attributed to withdrawal zone expansion. These results are consistent with measurements made by Duke Power at various projects on the Catawba River (Knight, 2002) as well as measurements made at TVA projects (Ruane et al, 1993.) Figure 23 shows how temperature in the discharges from Units 1, 3, and 4 increased as unit flow increased, and these results help confirm that withdrawal zone expansion caused the DO to increase in the turbine discharges.

Although withdrawal zone expansion is a significant consideration for achieving DO standards, the amount of DO that can be contributed to the turbine discharges from the project is dependent on water quality conditions in the lake. Figure 24 presents a summary of DO profiles that have been collected in the forebay of Lake Wylie during the months of July and August for the period 1993 through 2001, and the conditions during the 2002 turbine venting tests are plotted along with the historical profiles. These profiles indicate that the 2002 tests were conducted under worse or “near-worse” DO conditions in Lake Wylie. In comparing DO conditions in the lake and their potential negative impact on DO in the turbine discharges, it should be noted that worse case conditions occur when low DO near zero occurs high in the water column and/or when

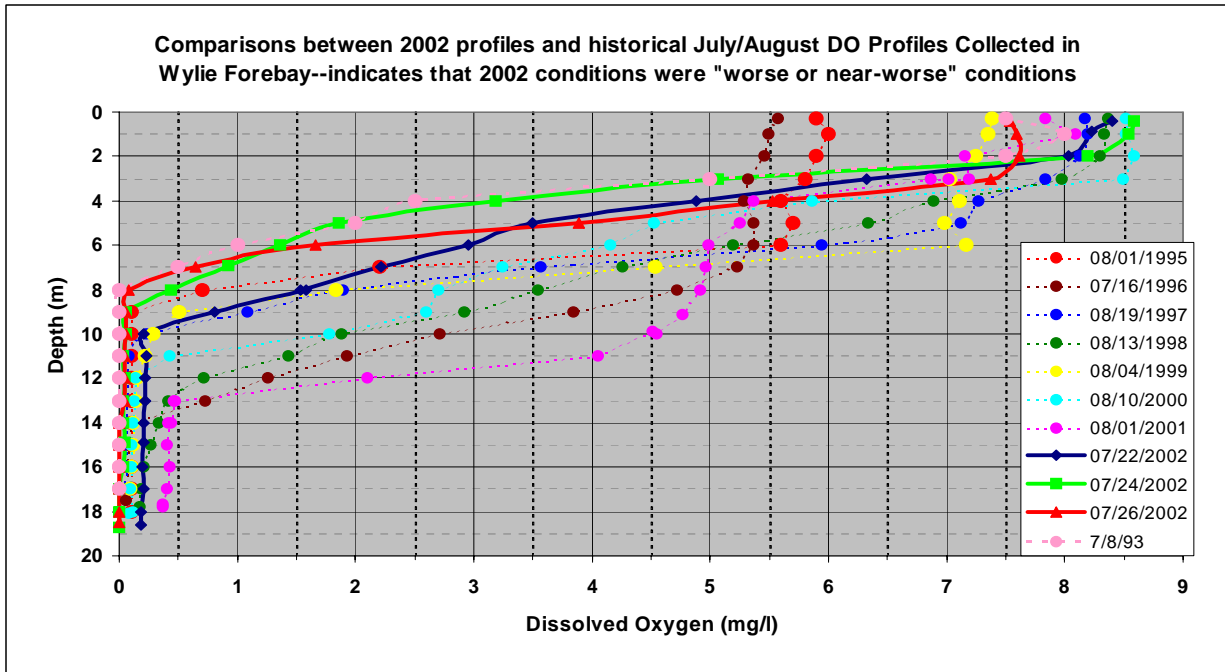
DO is low (i.e., 5 to 6 mg/L) in the upper part of the water column (i.e., the upper 4 to 6 m.). The profiles for 2002 indicate that DO in the upper part of the water column near the surface was near normal conditions; however, the low DO in the bottom layers of the lake deeper than 8 m was as low as any preceding year (i.e., the profile observed on July 8, 1993.)



**Figure 22: Withdrawal Zone Effects on Tailrace DO**



**Figure 23: Effect of Flow on Tailrace Water Temperature During Generation**



In determining worse case conditions, the temperature profile for the forebay must also be considered because it affects the density of the water layers and therefore the withdrawal zone expansion. Withdrawal zone modeling is needed to estimate the DO in the discharges considering the various DO and temperature profiles in the lake and then to determine which profile conditions yield the worse case DO conditions for the turbine discharges (Note to Duke reviewers: this modeling was supposed to be conducted under an expanded scope for this project during fiscal year 2002, but it was not completed by under the 2002 budget.)

## **CONCLUSIONS**

It appears that turbine aeration using air aspiration in conjunction with withdrawal zone expansion can achieve the DO water quality standard during periods when the turbines are operated, as long as Unit 4 is operated only after units 1, 2, and 3 are given preference for being operated first before Unit 4 is operated. However, it is conceivable that the amount of DO added using withdrawal zone expansion may not be sufficient under some conditions in the lake when DO is low in the upper layer of the lake or when low DO occupies a greater volume of the bottom of the lake than was observed during this study or any other time recorded in the past.

If additional aeration is needed to achieve the DO standard, the following additional turbine aeration measures could be considered:

- Adding more air supply piping and consider turbine modifications on Unit 1
- Investigating modifications to Unit 4 to induce more air.

**APPENDIX C**

**APPLICATION OF THE DISCRETE BUBBLE MODEL TO TURBINE  
AERATION ASSESSMENTS FOR THE CATAWBA-WATEREE PROJECT**

## **Application of the Discrete Bubble Model to Turbine Aeration Assessments for the Catawba-Wateree Project**

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## Introduction

Turbine venting has commonly been used to increase low dissolved oxygen (DO) in the releases from hydropower projects. It is estimated that some form of turbine venting is used or being planned at over 70 hydropower projects. It often is the preferred aeration method wherever it is applicable because other alternatives usually cost more, and project owners can more readily operate and maintain turbine venting systems.

Turbine venting systems were first used in the 1940s on the Fox River in Wisconsin, and this approach continues to be studied and advanced (Sheppard and Miller, 1982; Carter, 1995; Harshbarger, 1999; Thompson and Gulliver, 1997; Hopping et al., 1997 and 1999) to increase their effectiveness and address current issues.

Turbine aeration modeling has been used at selected projects to better understand and predict the performance of turbine venting systems (Raney, 1973; Sheppard et al, 1981; Quigley and Boyle, 1976; Wilhelms et al, 1987). These previous models were based on first-order gas transfer equations that accounted for mass transfer and the ratio of air flow to water flow. Thompson and Gulliver (1997) developed an approach that incorporates turbine system similitude considerations and tested it on one project.

In recent years the discrete bubble model (DBM) that accounts for bubble size in addition to the variables accounted for in the above models had been applied successfully to several lake aeration systems, so the authors applied it to turbine venting systems. The DBM has been verified with diffused-bubble oxygen transfer tests conducted in a tank, 14 meters deep, at three air flow rates. All of the test data were predicted to within 15% (McGinnis and Little, 2002). The range of bubble diameters during the test (0.2 to 2 mm) spanned the region of greatest variation in rise velocity and mass-transfer coefficient. This approach has subsequently been successfully applied to airlift aerators (Burris and Little, 1998; Burris et al., 2002), the Speece Cone (McGinnis and Little, 1998), linear and circular bubble-plume diffuser (Wüest et al., 1992; Little and McGinnis, 2001; McGinnis et al., 2001) and sidestream supersaturation systems (Mobley, 2001).

The first DBM applications to turbine aeration systems were for the Saluda Project near Columbia, SC. These applications included predicting DO in the turbine releases considering various turbine venting alternatives (2003), setting up and running the models to predict hourly concentrations of DO in an operational mode over representative hydrologic years (2003), and developing lookup tables for operators to use for aerating the releases from the project using the current turbine venting systems (2004-2007). The operational runs using various aeration

alternatives were used to assist in developing a site-specific water quality standard for DO in the Lower Saluda River downstream from the Saluda Project.

The DBM was selected for use on the Catawba-Wateree Project because it is believed that it has several advantages over previous turbine venting models for predicting aeration beyond the range of conditions for which data are available and the models are calibrated. DBM includes a more mechanistic description of the factors affecting gas transfer as described below; therefore, it should provide a better prediction of oxygen transfer for conditions lacking data (i.e., DO uptake at higher airflows; Lookout Shoals, Mountain Island; at lower water flows and new aerating wheels for the small units at Wylie and Wateree; and for new draft tubes at Linville). The DBM also offers the capability to test sensitivity of mass-transfer and initial bubble size to predicted conditions.

## Background

### Gas Exchange Theory and the Discrete-Bubble Model

The discrete bubble model, the foundation of the turbine aeration model, predicts gas transfer (both dissolution and stripping) across the surface of individual bubbles and simultaneously tracks both gaseous (bubble) and dissolved nitrogen and oxygen, but can easily include more gases (e.g., methane). The basic model equation has been described by many researchers [Leifer and Patro, 2002; McGinnis and Little, 2002; Vasconcelos et al., 2002; Wüest et al., 1992; Zheng and Yapa, 2002], with main differences being the parameterizations selected for the mass transfer coefficients, rise velocities, diffusivities and gas solubility.

The amount of gas transferred is a function of several factors, with the most important being gas partial pressure (defined here as the hydrostatic pressure  $\times$  mole fraction of gas), initial bubble size, and bubble-water contact time. The rate of change of the amount of gas in the bubble relative to depth and gas species is given as:

$$\frac{dF_{Gi}}{dz} = -K_{Li}(H_i P_i - C_i) \frac{4\pi r^2}{v + v_b} . \quad (1)$$

where,

$F_G$  = gas flux,

$K_L$  = mass transfer coefficient,

$H$  = gas solubility constant,

$P$  = pressure,

$C$  = dissolved gas concentration,  
 $r$  = bubble radius,  
 $v$  = velocity,  
 $z$  = depth,  
 $b$  = bubble  
 $i$  = gas species, oxygen or nitrogen

Note that in Equation 1,  $K_{L_i}$  and  $v_b$  are bubble size-dependent (Table 1). The term  $v$  is vertical component of water velocity in the turbine draft tube ( $v_b$  is positive in upward flowing water, negative in downward flowing water). The model was written in FORTRAN, and numerically integrated using the Euler method [McGinnis et al., 2006].

Table 1. Correlation equations for Henry's Law constant, mass transfer coefficient, and bubble rise velocity (Wüest et al., 1992)

Equation	Range
$K_O = 2.125 \times 10^{-5} - 5.021 \times 10^{-7}T + 5.77 \times 10^{-9}T^2$ (mol m <sup>-3</sup> Pa <sup>-1</sup> )	(T in Celsius)
$K_N = 1.042 \times 10^{-5} - 2.450 \times 10^{-7}T + 3.171 \times 10^{-9}T^2$ (mol m <sup>-3</sup> Pa <sup>-1</sup> )	
$K_{OL} = 0.6r$ (m s <sup>-1</sup> )	$r < 6.67 \times 10^{-4}$ m
$K_{OL} = 4 \times 10^{-4}$ (m s <sup>-1</sup> )	$r \geq 6.67 \times 10^{-4}$ m
$v_b = 4474r^{1.357}$ (m s <sup>-1</sup> )	$r < 7 \times 10^{-4}$ m
$v_b = 0.23$ (m s <sup>-1</sup> )	$7 \times 10^{-4} \leq r$
	$< 5.1 \times 10^{-3}$ m
$v_b = 4.202r^{0.547}$ (m s <sup>-1</sup> )	$r \geq 5.1 \times 10^{-3}$ m

### Size-Dependent Bubble Properties

Many parameterizations exist for rise velocity and mass transfer (See Leifer and Patro, 2002, for a thorough review of bubble experiments and theory); however, those selected for this model were done so based on their simplicity and reported accuracy. The present model uses rather simple correlation equations to determine terminal rise velocities of bubbles (Table 1) [McGinnis and Little, 2002; Wüest et al., 1992].

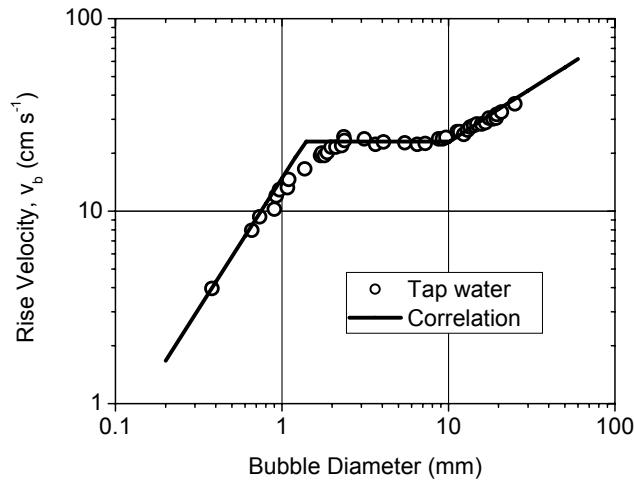


Figure 1. Measured rise velocities of bubbles with different sizes. A simple correlation was obtained for rise velocity as listed in Table 1 [after Wüest et al., 1992]. Data shown are from Haberman and Morton [1954].

Like bubble rise velocity, the rate of gas transfer across the bubble surface is also affected by many factors, including bubble size (surface area to volume ratio), internal gas circulation, rise velocity, and surfactants [Alves et al., 2005; Clift et al., 1978; Leifer and Patro, 2002; Vasconcelos et al., 2002; Vasconcelos et al., 2003]. The mass transfer coefficients for nitrogen and oxygen are equal and are the same equations used by Wüest et al. [1992] and McGinnis and Little [2002] (Figure 2). The simple approach of assuming correlation equations from the data in Figure 2 has been found to be appropriate for most shallow environments.

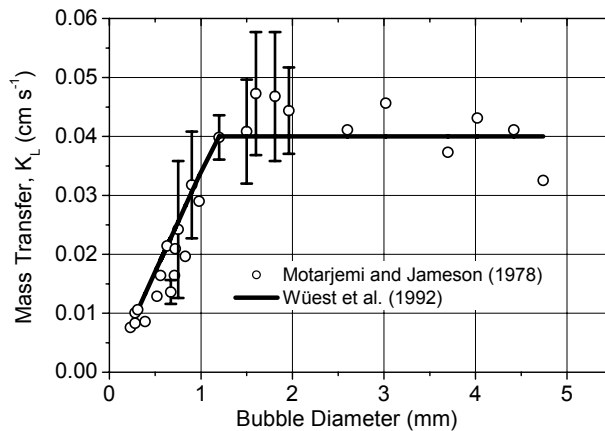


Figure 2. Mass transfer data for oxygen and nitrogen [Motarjemi and Jameson, 1978]. Solid line is correlation used by Wüest et al. [1992].

### Single Bubble Model Validation: Lab experiments

The bubble model was first validated using data collected in a laboratory setting, with shallow controlled conditions. McGinnis and Little [2002] bubbled air through water in a 14-m high by 2-m diameter tank with a porous hose diffuser and monitored the evolving oxygen

concentration. They first removed DO from the water by adding sodium sulfite. By doing this, they significantly increased the salinity of the water. Three different tests were performed with air at flow rates of 0.43, 0.68, and 2.88 Nm<sup>3</sup>/hr, (1 Nm<sup>3</sup> denotes 1 m<sup>3</sup> of gas at 1 bar and 0°C; Figure 3). No parameters were adjusted in the model to obtain the fit, demonstrating the models applicability to shallow fresh water.

### Model Application: Incorporation of Dissolved and Gaseous Fluxes

The discrete-bubble model provides fundamental principles that can be used for various aeration models. The basic bubble model has been expanded and applied to many aeration technologies with great success. These applications include the downward flow bubble contactor (i.e., Speece Cone) [McGinnis and Little, 1998], full-lift aerators [Burris and Little, 1998; Burris et al., 2002], bubble-plume diffusers [McGinnis et al., 2004; Wüest et al., 1992], side-stream super saturation systems for rivers (Mobley Engineering, Inc., personal communications, 2001), and turbine aeration units (this work).

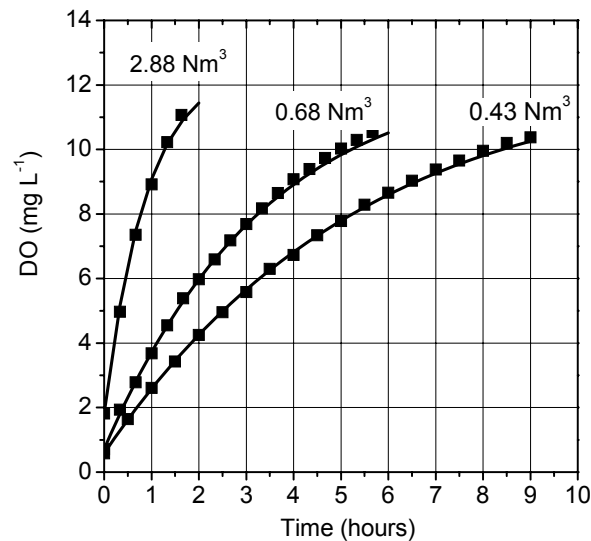


Figure 3. Data vs. the model prediction of DO transfer from bubbles into water. Data (symbols) are from McGinnis and Little [2002]. Model predictions account for inclusion of salinity in the calculation of the DO and Dissolved Nitrogen (DN) saturation concentrations.

Two basic equations common to all of the above-listed models are used to describe the gas and water fluxes as the bubbles travel through a pipe in two-phase flow.

Dissolved Gas Flux (DO and DN)	$\frac{dF_{Di}}{dz} = \frac{4\pi r^2 N}{(v + v_b)(1 - \varepsilon_g)} K_{Li} (H_i P_i - C_i)$
Gas Flux (DO and DN)	$\frac{dF_{Gi}}{dz} = - \frac{4\pi r^2 N}{v + v_b} K_{Li} (H_i P_i - C_i)$

$F_{Di}$  and  $F_{Gi}$  are the fluxes (mol/s) of the modeled dissolved and gaseous species (denoted by  $i$ ). For example, modeling oxygen and nitrogen would result in a set of four simultaneous differential equations.  $N$  is the number of bubbles per second in the system, and  $\varepsilon_g$  is the volumetric gas holdup, or void ratio, and is the volume of gas occupying a volume of water. This set of equations is then numerically integrated along the pipe (distance  $z$ ), based on the following set of assumptions:

1. The bubbles are produced at a constant rate, and remain uniformly distributed across the pipe.
2. Both water and bubbles are in plug flow, with negligible dispersion.
3. No bubble coalescence occurs, that is,  $N$ , the number of bubbles per second, remains constant.
4. For a given set of boundary conditions, the bubbles produced are uniform in size.
5. Temperature is assumed constant throughout the pipe.

### Application for Turbine Aeration

With the use of any models it should be recognized that modeling results provide a general indicator of what is likely to occur under given sets of conditions. As is the case in all aquatic environments, actual conditions are more complex than models, so models reproduce the major patterns that are observed in the field, and usually lack resolution, inputs, or formulations to reproduce all the minor patterns. Models are internally consistent and based on rigorous governing equations, so they can often help explain apparent discrepancies in field observations.

Based on the previously listed applications, it is obvious that the discrete bubble-model (DBM) approach is naturally suited to turbine aeration. This approach was first used by REMI in 2003 on the Saluda project with excellent results, and has since been applied to various other hydropower projects. See Figure 4 for schematic of bubble model application to turbine aeration.

One of the basic equations that determines bubble contact time and bubble location in the draft tube is

$$\frac{dz}{dt} = v + v_b$$

where  $z$  in this case is the centerline distance in the draft tube. It is important to note that the sign of the bubble rise velocity,  $v_b$  changes depending on the location in the draft tube and the direction of flow. In the case of vertical, downward flow, the sign of  $v_b$  is negative (the sign of the water velocity,  $v$ , is always positive), resulting in longer contact time as the bubble is “rising” in downward moving water. Where the draft tube is horizontal,  $v_b$  is set to zero. It was assumed that the bubbles are still dispersed in the water at this point. However, at lower water flow rates coalescence was mimicked by using a larger bubble size at lower flow velocities, which effectively reduced the surface area to volume ratio, simulating the effect of bubble coalescence. It should be noted also that bubble size should increase with decreasing draft tube velocity due to the lessening shear-effects on bubble size formation. For vertical, upward water flow, the sign of  $v_b$  is positive, resulting in shorter contact time as the bubble is now “rising” in the same direction as the moving water.

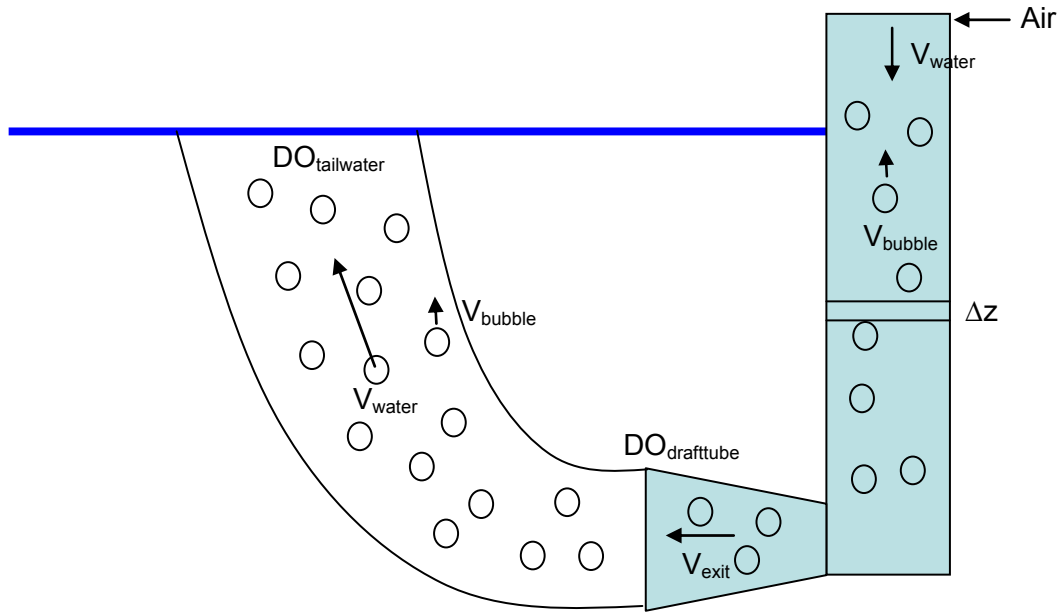


Figure 4. Schematic of bubble model application to turbine aeration.

Aeration in the tailwater is calculated by assuming the bubbles rise vertically, with some induced vertical water velocity. Preliminary jet-plume modeling and experience has shown that this assumed vertical water velocity is generally about 50 percent of the velocity at the exit of the draft tube.

## General Calibration Procedure

The model has been applied to several hydropower projects with excellent success. The calibration procedure and details are listed in the next section using Saluda and Wylie as examples. However, generally, the process is as follows:

1. The geometry of the draft tube is developed and incorporated into the DBM program.
2. Using measured inflow and outflow DOs, measured airflow, temperature, turbine flow, and tailwater elevation, the model is iteratively run to determine the bubble size that most closely yields the measured DO. The initial bubble size vs. initial unit water velocity is then plotted (Figure 5). The resulting data have been found usually to fit a good trend, such as the power relation determined for Wylie and Saluda.
3. The model is run using the bubble size versus velocity relationship, and model prediction errors are determined by comparing predictions with data.

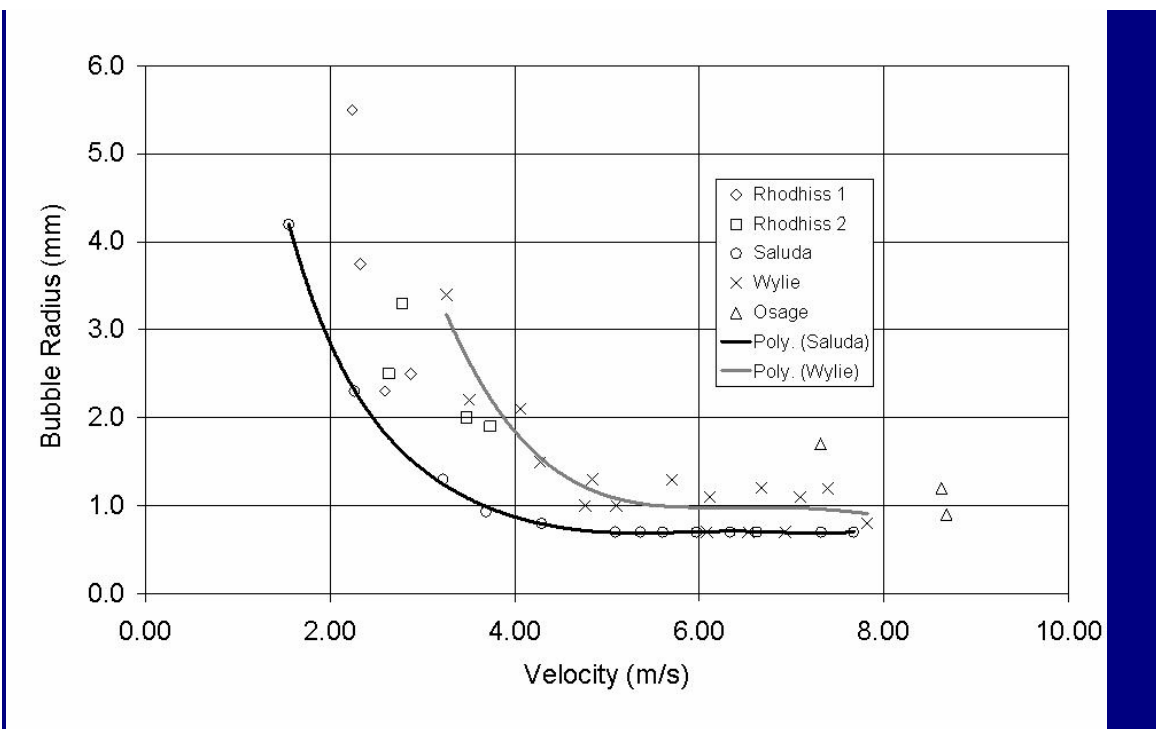


Figure 5. Resulting bubble size vs. initial velocity for Wylie, Saluda, and other projects.

#### Calibration of DBM Model to Wylie and Saluda

Table 2 lists the input data and model predictions for Saluda and Wylie. The tailrace DO includes the influent DO, DO added in the draft tube by air bubbles, and the DO addition in the tailrace due to additional oxygen transfer from bubbles, as well as any surface reaeration and entrainment by the discharge plume. As the first iteration of the calibration, the initial bubble size vs. draft tube velocity is estimated by fitting the model to the measured tailrace (TR) DO using the influent DO listed in Table 2.

Model Input Boundary Conditions							Measurements		Model Output Predictions				
Run No.	TWE	Discharge	Velocity	Air Flow	Temperature	DO in	DO	TDG	Entrainment Factor, E	DO	OTE	Bubble Radius	TDG
	Feet	cfs	ft/s	cfs	°C	mg/L	mg/L	%	-	mg/L	%	mm	%
16	176.0	637	5.1	89	17.1	0.16	6.50	107	0.50	6.5	15	4.2	108
17	175.8	928	7.4	97	17.0	0.16	6.23	107	0.50	6.2	20	2.3	107
18	175.6	1322	10.6	96	17.2	0.16	5.70	105	0.50	5.7	26	1.3	105
19	175.4	1515	12.1	88	17.2	0.16	5.40	104	0.50	5.4	31	0.9	104
20	175.4	1761	14.1	88	17.2	0.16	4.75	102	0.50	4.8	32	0.8	101
21	175.3	2090	16.7	91	17.4	0.16	4.40	101	0.40	4.4	34	0.7	98
22	175.6	2200	17.6	91	17.4	0.16	4.13	99	0.40	4.1	33	0.7	98
23	175.8	2300	18.4	92	17.4	0.16	4.02	97	0.37	4.0	23	0.7	97
24	175.8	2450	19.6	94	17.4	0.16	3.91	97	0.31	3.9	34	0.7	97
25	175.9	2600	20.8	97	17.4	0.16	3.95	97	0.24	4.0	37	0.7	97
26	175.9	2719	21.7	100	17.4	0.16	3.94	97	0.20	4.0	36	0.7	98
27	176.0	3004	24.0	80	17.4	0.16	3.60	96	0.08	3.7	46	0.7	96
28	176.1	3149	25.2	77	17.4	0.16	3.64	96	0.05	3.7	50	0.7	96

1	494.6	1565	11.5	62	27.5	3.70	5.59	113	0.50	5.6	17	2.6	113
1	494.8	1907	14.0	55	27.7	3.40	5.33	110	0.50	5.3	24	1.5	110
1	494.7	2123	15.6	53	27.8	3.60	5.36	110	0.50	5.4	26	1.2	110
1	494.9	2275	16.7	48	27.9	3.30	4.98	107	0.50	5.0	29	1.1	107
1	495.0	2713	19.9	50	28.0	3.50	4.95	105	0.50	4.9	27	1.0	104
1	495.2	2914	21.4	50	28.1	3.70	4.87	102	0.50	4.9	25	1.0	103
1	495.3	3092	22.7	50	28.1	3.60	4.72	101	0.50	4.7	25	1.0	101
3	494.2	1455	10.7	106	27.5	3.00	5.95	120	0.50	6.1	15	3.2	120
3	494.5	1809	13.3	99	27.7	2.70	5.89	120	0.50	6.0	21	1.8	120
3	494.6	2160	15.9	90	27.8	2.70	5.76	119	0.50	5.8	26	1.2	119
3	495.1	2544	18.7	100	28.0	2.30	5.44	114	0.50	5.4	28	1.0	115
3	495.2	2724	20.0	108	28.0	2.70	5.61	116	0.50	5.6	26	1.0	115
3	495.5	2976	21.9	143	28.1	2.40	5.72	114	0.50	5.7	24	1.0	114
3	495.5	3163	23.2	143	28.1	2.70	5.63	113	0.50	5.6	23	1.0	113
3	495.6	3298	24.2	133	28.2	2.50	5.18	107	0.50	5.2	24	1.0	107
3	495.7	3489	25.6	94	28.3	3.80	5.36	109	0.50	5.5	22	0.9	109

Table 2. Input data and model results for Saluda Unit 1 (top panel) and Wylie Units 1 and 3 (bottom panel).

To estimate the bubble aeration in the tailrace, the circle bubble plume model [McGinnis et al., 2004; Wüest et al., 1992] was used for several cases using the discharge velocity and bubble conditions, with 50 percent of the exit velocity generally found to be a good approximation for the discharge plume in the tailrace. This 50 percent has been found to be a good approximation for other projects.

For both projects, the model reproduced the measured tailwater DO remarkably well (Table 2 and Figure 6). The effect of the TWE is incorporated into the model.

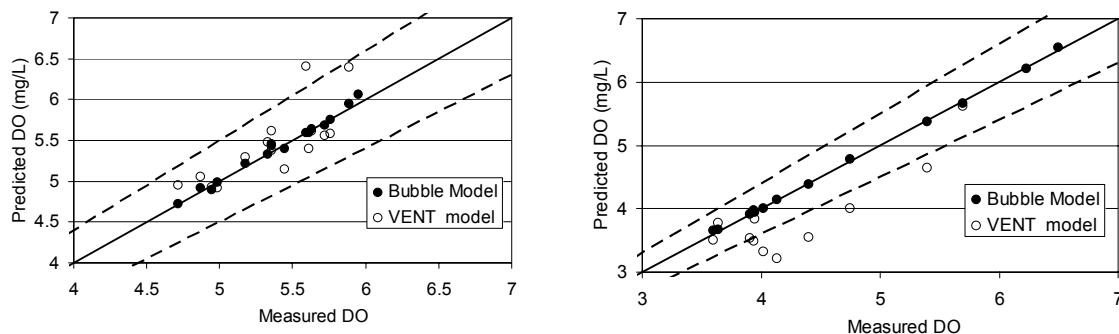


Figure 6. Predicted vs. measured values for using the DBM and the USACE model. Left

panel: Wylie; right panel: Saluda

### DO Predictions for Other Facilities of the Catawba-Wataree Project

In 2006, turbine venting studies were conducted on representative units at Rhodhiss, Oxford, Lookout Shoals, Fishing Creek, Dearborn, Cedar Creek, and Wateree. Turbine venting studies conducted in 2002 were used to calibrate the model for Wylie. The DBM model was calibrated to the data collected on each unit studied at each facility, and the results are presented in Table 3 and Figure 7.

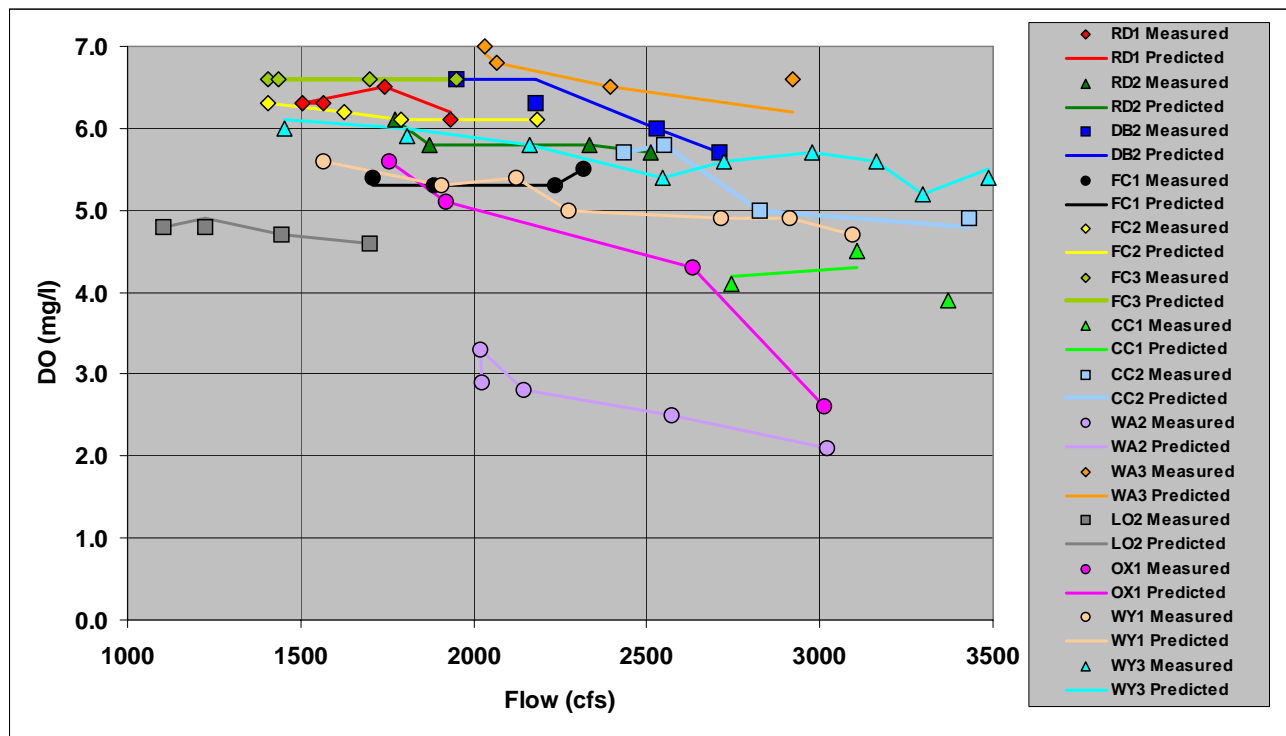


Figure 7. Measured and predicted DO values for each turbine unit studied on the Catawba-Wataree system

Run	Q	Airflow	DOin	Temperature	TWE	Measured DO out	Predicted DO	Bubble Radius	Gas Holdup	Initial Velocity	Horizontal Avg Velocity
	cfs	cfs	mg/L	°C	ft-msl	mg/L	mg/L	mm	%	ft/s	ft/s
RD 1											
4	1,565	68.3	4.9	25.2	932.0	6.3	6.3	3.8	4.6	7.6	2.8
6	1,505	69.9	5.2	25.1	932.0	6.3	6.3	5.5	4.9	7.3	2.7
8	1,743	62.5	4.8	25.0	932.0	6.5	6.5	2.3	3.8	8.5	3.2
10	1,931	58.4	4.9	25.0	932.0	6.1	6.2	2.5	3.2	9.4	3.5
RD 2											
4	1,773	74.7	4.1	24.4	932.0	6.1	6.1	2.5	4.5	8.6	3.2
6	1,872	79.4	4.3	24.4	932.0	5.8	5.8	3.3	4.4	9.1	3.4
8	2,336	78.5	4.2	24.4	932.0	5.8	5.8	2.0	3.5	11.4	4.2
10	2,511	77.7	4.3	24.4	932.0	5.7	5.7	1.9	3.3	12.2	4.6
FC U1											
4	1,710	22.3	4.6	27.3	356.0	5.4	5.3	2.3	1.8	16.8	3.1
6	1,885	21.8	4.7	27.4	356.0	5.3	5.3	2.0	1.7	18.5	3.4
8	2,236	31.5	4.6	27.5	356.0	5.3	5.3	2.0	2.1	21.9	4.0
10	2,318	25.9	4.6	27.5	356.0	5.5	5.5	1.2	1.6	22.7	4.1
FC U2											
4	1407	84.3	4.1	27.9	356.0	6.3	6.3	4.0	8.6	13.8	2.5
6	1626	86.0	4.7	27.9	356.0	6.2	6.2	4.5	7.6	15.9	2.9
8	1792	88.2	4.7	27.9	356.0	6.1	6.1	4.0	7.1	17.6	3.2
10	2184	89.1	4.8	27.7	356.0	6.1	6.1	3.0	5.9	21.4	3.9
FC U3											
4	1404	78.2	4.8	27.6	356.0	6.6	6.6	4.0	8.0	13.8	2.5
6	1435	76.5	5.3	27.6	356.0	6.6	6.6	5.5	7.6	14.1	2.6
8	1701	83.5	5.5	27.6	356.0	6.6	6.6	5.0	7.1	16.7	3.0
10	1952	82.9	5.2	27.6	356.0	6.6	6.6	3.0	6.1	19.1	3.5
DB U2											
4	1,948	81.3	4.9	28.7	283.0	6.6	6.6	4.0	4.6	9.5	3.3
6	2,177	87.7	4.9	28.7	283.0	6.3	6.6	3.5	4.5	10.6	3.7
8	2,530	84.3	4.6	28.7	283.0	6.0	6.0	3.5	3.7	12.3	4.3
10	2,708	78.0	4.6	28.7	283.0	5.7	5.7	3.9	3.2	13.2	4.6
LO U2											
4	1103	9.4	4.3	26.5	765.0	4.8	4.8	2.5	1.1	16.5	2.1
6	1224	9.6	4.6	26.5	765.0	4.8	4.9	4.5	1.1	18.3	2.4
8	1444	9.3	4.5	26.5	765.0	4.7	4.7	5.0	0.8	21.6	2.8
10	1698	5.6	4.5	26.5	765.0	4.6	4.6	5.0	0.5	25.3	3.3
OX U1											
4	1756	96.9	2.6	26.4	843.1	5.6	5.6	0.8	5.5	14.3	4.5
6	1919	91.9	3.1	26.4	843.2	5.1	5.1	1.0	4.8	15.6	5.0
8	2631	78.2	2.2	26.3	843.4	4.3	4.3	0.4	3.0	21.4	6.8
10	3014	0.0	2.2	26.3	843.6	2.6	2.6	0.4	0.0	24.6	7.8
WY U1											
3	1565	61.8	3.7	27.5	494.6	5.6	5.6	2.6	3.9	11.0	3.6
6	1907	55.2	3.4	27.7	494.8	5.3	5.3	1.5	2.9	13.4	4.3
7	2123	53.2	3.6	27.8	494.7	5.4	5.4	1.2	2.5	14.9	4.8
10	2275	48.1	3.3	27.9	494.9	5.0	5.0	1.1	2.1	16.0	5.2
11	2713	49.8	3.5	28.0	495.0	4.9	4.9	1	1.8	19.1	6.2
14	2914	50.3	3.7	28.1	495.2	4.9	4.9	1	1.7	20.5	6.6
15	3092	50.1	3.6	28.1	495.3	4.7	4.7	1	1.6	21.7	7.0
WY U3											
55	1455	105.9	3.0	27.5	494.2	6.0	6.1	3.2	7.3	10.2	3.3
58	1809	99.0	2.7	27.7	494.5	5.9	6.0	1.8	5.5	12.7	4.1
59	2160	89.8	2.7	27.8	494.6	5.8	5.8	1.2	4.2	15.2	4.9
62	2544	100.0	2.3	28.0	495.1	5.4	5.4	1	3.9	17.9	5.8
63	2725	108.1	2.7	28.0	495.2	5.6	5.6	1	4.0	19.2	6.2
66	2976	142.9	2.4	28.1	495.5	5.7	5.7	1	4.8	20.9	6.8
67	3163	142.8	2.7	28.1	495.5	5.6	5.6	1	4.5	22.2	7.2
70	3298	132.8	2.5	28.2	495.6	5.2	5.2	1	4.0	23.2	7.5
71	3489	94.2	3.8	28.3	495.7	5.4	5.5	0.9	2.7	24.5	7.9
WA U2											
4	2024	33.6	1.9	28.2	143.5	2.9	2.9	1.4	3.0	15.3	5.8
6	2021	39.9	1.9	28.2	143.5	3.3	3.3	1.2	3.5	15.3	5.8
8	2145	38.9	1.9	28.4	143.5	2.8	2.8	1.7	3.2	16.3	6.2
10	2573	37.2	1.9	28.4	143.5	2.5	2.5	1.7	2.6	19.5	7.4
11	3021	19.3	1.9	28.5	143.5	2.1	2.1	2.0	1.1	22.9	8.7
WA U3											
4	2030	170.8	2.9	28.0	143.5	7.0	6.9	0.5	8.4	15.4	5.9
6	2065	209.8	2.9	28.1	143.5	6.8	6.8	1.1	10.2	15.7	6.0
8	2396	247.0	2.9	28.2	143.5	6.5	6.5	1.2	10.3	18.2	6.9
10	2920	232.8	2.9	28.2	143.5	6.6	6.2	0.5	8.0	22.1	8.4
CC U1											
4	2744	19.8	3.5	29.6	222.0	4.1	4.2	0.7	0.8	20.2	7.8
6	3108	19.4	3.8	29.6	222.0	4.5	4.3	0.7	0.7	22.8	8.8
8	3369	0.2	4.2	29.7	222.0	3.9	-	-	-	-	9.5
CC U2											
4	2433	58.3	3.7	29.5	222.0	5.7	5.7	0.7	2.6	17.9	6.9
6	2548	50.5	4.3	29.5	222.0	5.8	5.8	0.7	2.1	18.7	7.2
8	2825	51.3	4.3	29.8	222.0	5.0	5.0	1.8	2.0	20.7	8.0
10	3429	23.7	4.3	30.1	222.0	4.9	4.8	0.7	0.8	25.2	9.7

Table 3. Summary of data collected and other model inputs determined to develop DBM predictions. The first four projects are grouped together because they have lower horizontal velocities.

As can be seen in Figure 7 and Table 3, the model was calibrated so that it matched the DO data in the tailrace (i.e., DOout). This calibration approach was used so that the model would essentially match the data for the field conditions under which the data were collected.

When the models were used for model runs, the bubble radius values for intermediate unit flow levels were interpolated between those flow levels tested. This approach is deemed most appropriate for the objectives for this modeling, i.e., to simulate DO in the releases from the units for a wide range of conditions (i.e., hourly flows, inflow DOs, and temperature) over a period years. Also, for most of the units studied there were four gate settings studied so there were insufficient data to develop regression relationships between values of  $r_b$  and unit velocities.

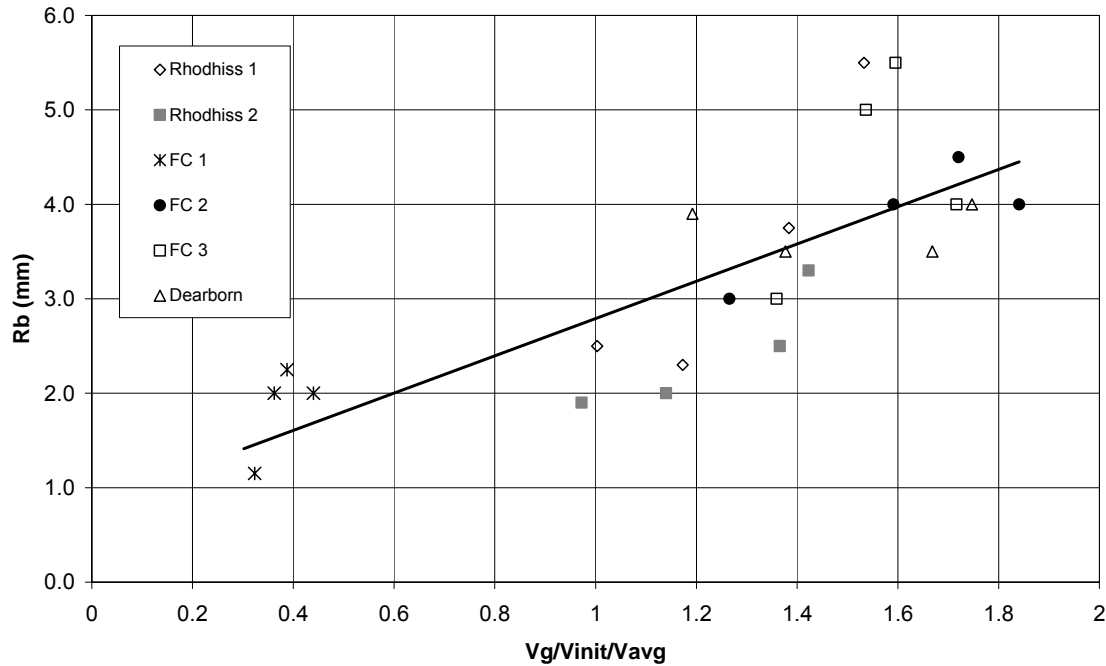


Figure 8. Relationship developed between  $r_b$  and variables considered to be important for turbine venting:  $V_g$ , gas void ratio;  $V_{init}$ , initial velocity in the draft tube; and  $V_{avg}$ , the average velocity in the draft tube. This relationship was used to develop DBM for LO and MI.

Data were not available to calibrate the DBM model for Lookout Shoals (LO) because turbine venting has not yet been installed or for Mountain Island (MI) because turbine venting had not yet been installed at the time the studies were conducted. These facilities have short draft tubes without the traditional relatively deep elbow and their water velocities in the horizontal sections were lower than those for more traditional draft tubes, so the  $r_b$  relationships with initial velocity as shown for Saluda and Wylie were not used. Three of the facilities studied did have draft tubes that had similar appearance to those for LO and MI: Rhodhiss, Fishing Creek, and Dearborn. The  $r_b$  values for these projects were higher than for those with more traditional units. To estimate the  $r_b$  values for Lookout and Mountain Island, the relationship shown in Figure 8 was developed between  $r_b$  and  $(V_g/V_{init}/V_{avg})$  based on the study results for RD, FC, and DB. The DBM was then used to estimate the amount of airflow needed to attain the

DO objective and these airflow values were reviewed to assess whether they reasonably could be provided using turbine venting. In each case the airflows were considered to be reasonable.

During model runs (hourly time series simulations), the above curve was used as a sensitivity analysis for the facilities listed in the legend. This was a more conservative approach than using the bubble sizes from the calibration shown in the Table 3. While these facilities do have draft tubes that are different from “traditional” projects, the reason is not exactly clear, and is likely due to a combination of several factors. These factors could be:

1. Geometry of the draft tube, particularly if there is a horizontal section where bubbles can accumulate at the top which violates the model assumptions.
2. Low average velocities in the draft tube, especially in horizontal sections – related to point 1).
3. Low initial velocities where air is introduced tends to produce larger bubbles.
4. High gas hold up,  $V_g$ , which is the air to water ratio. The higher this value becomes, the more likely bubble coalescence will occur, especially considering points 1, 2, and 3.
5. Low turbulence at point of air introduction. This is also related to wall roughness or the lack of sharp (90 degree or so) bends, which also tend to keep bubbles broken up and help prevent coalescence.
6. If bubbles and gas accumulate at the top of horizontal sections of the draft tube, then this gas is released as very large bubbles in the tailrace, greatly reducing gas transfer.

To try to account for these effects, the correlation in Figure 8 was developed to estimate  $r_b$  values for the units studied at RD, DB, and FC for all the runs. This was used as a sensitivity test in addition to the results of bubble size resulting from model calibration shown in Table 3.

The air flows measured during the single unit studies are plotted versus unit flow in Figure 9. These are the airflows that were used to calibrate DBM for each unit. Air flows are often sensitive to TWE, so measurements of airflow were made at various TWEs for each unit during the study and these were used to develop relationships between airflow and TWE that were used in DBM operational runs for total plant operations. For model runs, TWE was determined by using a relationship between TWE and total project flow.

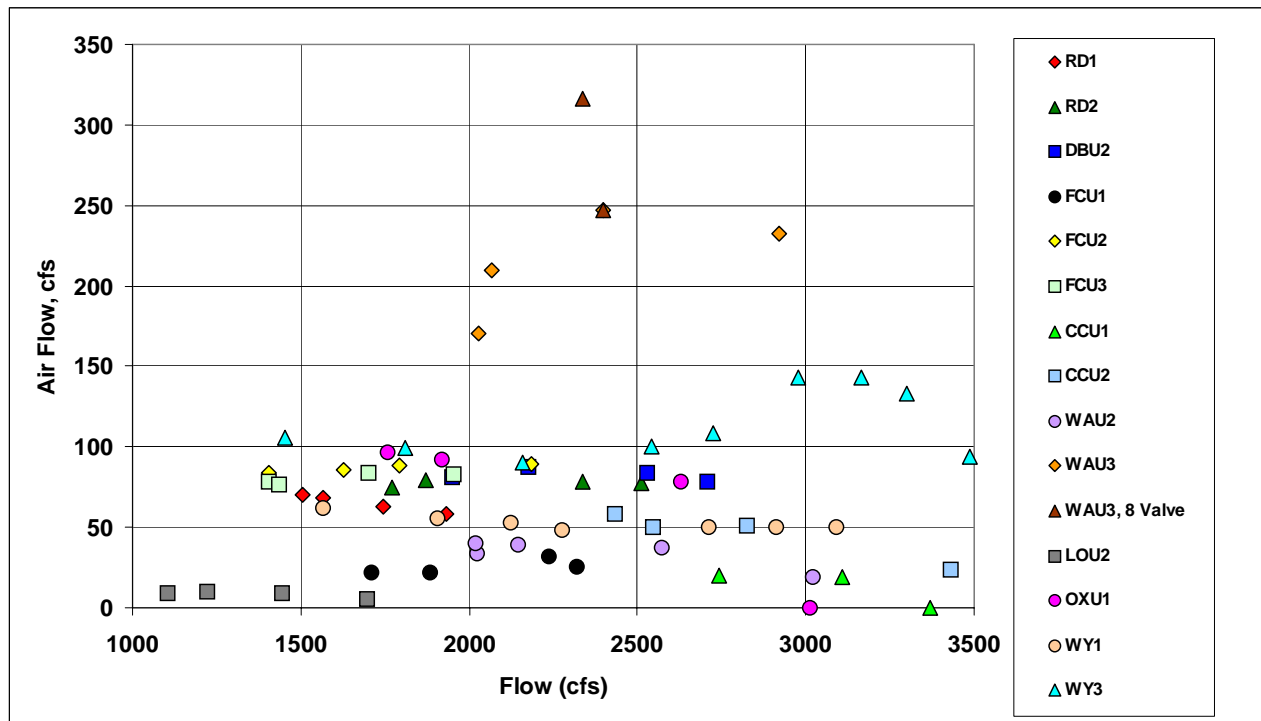


Figure 9. Airflows measured during the 2002 and 2006 studies

## USACE “VENT” Model

Wilhelms et al. [1987] presented a turbine venting model “VENT” based on developments in the 1970s and 1980s by Alabama Power Company (Raney, 1975) and the U.S. Army Corps of Engineers (USACE). This model is a first-order gas transfer model commonly used for simulating DO in waterways where the gas exchange coefficient is calibrated using data from tests for that particular site. To account for the change in the gas exchange coefficient due to various amounts of air that might be drawn into the turbine, they used the ratio of the air flow to water flow and a coefficient of gas transfer in place of the gas exchange coefficient.

The procedure for setting up the VENT model is relatively straightforward and firstly involves developing a pressure-time curve based on the draft tube geometry, and the “base” flow conditions (TWE,  $Q$ , and travel time). The user then enters the boundary conditions into the model input file (TWE,  $DO_{in}$ ,  $T$ ,  $Q_{water}$  and  $Q_{air}$ ). Comparing the model to measured values, the user can adjust two calibration parameters (see Wilhelms et al. [1987] for more details):

1. Alpha, the estimate of the gas transfer coefficient, and
2. Beta, the energy dissipation coefficient for turbulence.

Figure 7 compares the VENT DO predictions with the DBM predictions.

The DBM was selected for use because it is believed that it has several advantages over the VENT model for predicting aeration beyond the range of conditions for which data are

available. DBM includes a more mechanistic description of the factors affecting gas transfer, i.e., bubble size; therefore, it should provide a more robust prediction of oxygen transfer for situations lacking data and for variable turbine venting conditions (i.e., water flow rates, air flow rates, and draft tube geometry). The DBM also offers the capability to test sensitivity of mass-transfer and initial bubble size to predicted conditions. Under certain conditions, the VENT model does have reasonable predictive capabilities (Figure 7); however, it consistently overpredicts in cases of low flows (i.e., low draft tube velocities) and in some cases very high gas to flow ratios (Figure 7). Nonetheless, the model is used in parallel with the DBM as a cross check.

## CONCLUSIONS

Results obtained by using DBM were compared to data collected at Wylie and Saluda Hydros. The key model inputs were the gas flow rate, water flow rate, draft tube geometry, as well as temperature, DO, and tailwater elevation. Using measured field data from a wide range of gate settings, an initial bubble size vs. turbine flow rate (initial water velocity at the entrance to the draft tube) was developed. Based on correlation equations for bubble-rise velocity and the mass-transfer coefficient developed by Wüest et al. (1992), the model predicted the output DO at Wylie and Saluda within 10 percent of the observed values. These results provided evidence that the model was capable of simulating DO uptake in a robust and reliable manner that is satisfactory for decision making regarding water quality management.

The model was then calibrated to turbine aeration data collected in 2002 for two units at Wylie and in 2006 for twelve hydropower units at other Duke facilities. In this case, the model was calibrated to each data point so that predictions for model runs would be as accurate as possible.

The discrete-bubble model has been successfully used to predict oxygen transfer in turbine aeration applications (this work, the Saluda Project, Osage Hydro, Brownlee Hydro, and three Mirant-NY projects), an airlift aerator (Burris et al., 2000), and a line bubble plume (Little and McGinnis, 2001). A calibrated DBM for turbine aeration is a useful tool to predict the effectiveness of turbine upgrades, for assessment studies for attaining DO objectives in turbine releases, and for predicting air flows required to attain DO objectives. The model can be used for a range of project hourly operations and water quality conditions that affect turbine aeration performance.

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**APPENDIX D**

**THE SANTEE RIVER BASIN ACCORD FOR DIADROMOUS FISH  
PROTECTION, RESTORATION, AND ENHANCEMENT**

# **SANTEE RIVER BASIN ACCORD FOR DIADROMOUS FISH PROTECTION, RESTORATION, AND ENHANCEMENT**

## **General**

The Santee River Basin Accord (“Accord”) is a collaborative approach among utilities with licensed hydroelectric projects, and federal and state resource agencies to address diadromous fish protection, restoration, and enhancement in the Santee River Basin (“Basin”). This Accord supports the *Santee-Cooper Basin Diadromous Fish Passage Restoration Plan* (2001) which was developed by the South Carolina Department of Natural Resources (“SCDNR”), the National Oceanic and Atmospheric Administration’s National Marine Fisheries Service (“NMFS”), and the United States Fish and Wildlife Service (“USFWS”), and was accepted as a Comprehensive Plan by the Federal Energy Regulatory Commission (“FERC”) as noted in the FERC’s letter to the USFWS dated October 3, 2001.

Accord participants and hydroelectric projects (referred to herein singularly as “Project” and together as “Projects”) that are the subject of this Accord include South Carolina Electric & Gas Company (“SCE&G”), licensee of the Saluda Hydroelectric Project No. 516, the Parr Hydroelectric Project No. 1894, and the Neal Shoals Hydroelectric Project No. 2315, and Duke Energy Carolinas, LLC (“Duke”), licensee of the Catawba-Wateree Hydroelectric Project No. 2232, the Ninety-Nine Islands Hydroelectric Project No. 2331, and the Gaston Shoals Hydroelectric Project No. 2332 (SCE&G and Duke referred to herein singularly as “Utility” and together as “Utilities”) and their successors; and the SCDNR, the North Carolina Wildlife Resources Commission (“NCWRC”), and the USFWS (referred to herein singularly as “Agency” and together as “Agencies”) and their successors. Singularly, any Utility or Agency that signs this Accord may be referred to herein as “Party”. Collectively, the Utilities and Agencies that sign this Accord constitute the Cooperative Accord Partnership (“CAP” or “Parties”). The NMFS and the South Carolina Department of Health and Environmental Control (“SCDHEC”) were also involved in the development of this Accord, but neither are currently signatories to the Accord and are therefore not CAP members. Future CAP members, if any, will be limited to federal and state resource agencies with authority for any diadromous fish species and their habitats in the Basin, and to owners of other FERC-licensed hydroelectric projects in the Basin. Non-governmental organizations and the general public will not be members of the CAP, but may participate via consultation with CAP members and may attend CAP meetings in a non-decision-making role. However, all discussions by non-CAP members in CAP meetings will be limited to a short public comment period (to include submission of written comments, if desired) at the start of a meeting, unless the CAP agrees by consensus on a case-by-case basis to do otherwise.

This Accord constitutes an agreement among the CAP members for the protection, restoration, and enhancement of diadromous fish in the Basin through implementation of a 10-year Action Plan (“Plan”) that was initially developed by the USFWS (*Cooperative Accord 10-Year Action Plan For The Restoration and Enhancement of Diadromous Fish In The Santee Basin*—original draft dated January 24, 2007), and that includes no-sooner-than dates and biological triggers for fish passage as specified in this document. Tasks and cost estimates for each activity in the Plan are shown in Appendix A, and no-sooner-than dates, biological triggers, and other agreed-upon actions are noted in Appendix B. The agreements, activities, and biological studies identified in

the Accord, and in Appendices A, B, and C which are hereby incorporated by reference, will be used to support the development of fish passage prescriptions that will protect, restore, and enhance diadromous fish species in the Basin and will be filed with the FERC for inclusion in the new licenses for some of the above-referenced Projects. The CAP members have worked to create this Accord to meet the interests of CAP members while still allowing all Agencies and Jurisdictional Bodies to meet their respective statutory obligations for diadromous fish under §7 of the Endangered Species Act (“ESA”) and under §4(e), §10(a), §10(j), and §18 of the Federal Power Act (“FPA”), and under §401 of the Clean Water Act (“CWA”), for the above-referenced Projects. The CAP has agreed to implement phased, deliberate, and effective activities that will initiate diadromous fish population enhancements in the near-term while collecting data and monitoring diadromous fisheries over a longer period for optimizing further restoration efforts.

## **Definitions**

Consensus—a vote with no dissenting votes; abstention by a member is not a dissenting vote.

Jurisdictional Body—any governmental body, except Agencies, which has the authority to bind the Utilities by imposing requirements affecting the operation of the Projects that are the subject of the Accord.

Existing Project License—the hydropower license that as of the effective date of this Accord has been issued by the FERC for Projects No. 1894, No. 2315, No. 2331, and No. 2332 but does not include subsequent or renewed licenses, or their terms, even if some or all of the terms of a subsequent or renewed license are identical to terms in an Existing Project License.

Inconsistent Act—(A) any requirement, condition, prescription, or recommendation imposed by a Jurisdictional Body pursuant to §§4(e), 10(a), 10(j), or 18 of the FPA, §7 of the ESA, or §401 of the CWA for operation of a Project that materially varies any obligation concerning the restoration of diadromous fish, reservoir elevation limitations, required flow releases, and low inflow protocols or high inflow protocols from those set forth in the Catawba-Wateree Comprehensive Relicensing Agreement (CRA), as amended on December 29, 2006, or in an Existing Project License; or (B) any requirement, condition, prescription, or recommendation imposed by a Jurisdictional Body pursuant to §§4(e), 10(a), 10(j), or 18 of the FPA, §7 of the ESA, or §401 of the CWA that materially varies any obligation from those set forth in this Accord.

Breach—a failure of a Party to comply with the terms of the Accord in a significant and non-trivial manner and includes, but is not limited to: (A) a requirement, condition, prescription, or recommendation for a Project that is imposed by an Agency pursuant to §§4(e), 10(a), 10(j), or 18 of the FPA, or §7 of the ESA that materially varies any obligation set forth in this Accord; or (B) any CAP member’s requesting, promoting, or supporting an Inconsistent Act or other requirements that materially varies any obligation set forth in this Accord.

Materially Vary or Varies—a requirement, condition, prescription, or recommendation materially varies if it imposes additional obligations that in the discretion of the affected Utility are significant and includes, but is not limited to: (A) reservoir elevation limitations; required flow releases; low inflow protocols or high inflow protocols that are significantly different from

those in the CRA or in an Existing Project License (whether by changing the actual obligation or by changing the method of implementing the obligation); (B) upstream or downstream passage of diadromous fish at a Project dam on a schedule different from that identified in the Accord; (C) installation of fishway equipment on a Project dam that is in addition to or different from what is required by the Accord; or (D) fish studies, monitoring, or analyses that are in addition to or different from what is required by the Accord.

Fish Passage Facilities, Fishways, and Prescriptions— defined in *Notice of Proposed Interagency Policy on the Prescription of Fishways Under Section 18 of the Federal Power Act*, (Federal Register/Volume 65, No. 247/Friday, December 22, 2000) for existing hydroelectric projects on the Saluda, Broad, and Catawba-Wateree rivers. These terms are used interchangeably throughout this document.

## **Key Agreements**

The CAP members agree as follows:

### General Agreements

1. The Utilities will not pursue Trial Type Hearings (“TTH”) before an Administrative Law Judge pursuant to FPA §§4(e) or 18 to contest the USFWS’s FPA §§4(e) or 18 diadromous fish requirements so long as the USFWS’s ESA §7 requirements, FPA §§4(e) conditions, 10(a) and 10(j) recommendations, and 18 prescriptions do not materially vary reservoir elevation limitations, required flow releases, low inflow protocols or the high inflow protocols as set forth in: (A) the CRA; (B) Existing Project Licenses at the Ninety-Nine Islands and Gaston Shoals Projects; (C) a settlement agreement among the SCDNR, the USFWS, and SCE&G for the Saluda Hydroelectric Project; and (D) this Accord.
2. The Plan, which emphasizes research on fish movement (both upstream and downstream), distribution, and habitat use; fish population enhancement and restoration activities; and related funding responsibilities for American eels, American shad, Atlantic sturgeon, blueback herring, and shortnose sturgeon, will be implemented.
3. The Accord’s no-sooner-than dates and biological triggers (in Appendix B) will be used to initiate conceptual design and subsequent construction of fish passage facilities for existing hydroelectric Projects on the Broad River and the Catawba-Wateree River.
4. The restoration target numbers for adult anadromous American shad and adult anadromous blueback herring restoration in the Broad River are set in Appendix C.
5. Subject to limitations regarding confidential and proprietary information, the CAP will establish and maintain a publicly accessible electronic archive for all data and documents created as a result of the Accord. When requested by a Utility, the Agencies will treat specific data provided by the Utility as confidential and proprietary, to the extent permitted by law. This may include pre-decisional work products, proprietary information, and sensitive resource data. In the event that any confidential or proprietary information is required by law to be released by an Agency, that Agency shall provide

CAP members affected by such a release with at least a 30-day written notice in advance of such release, unless a shorter notice period is required by law. Nothing herein shall be interpreted to prevent any Agency from complying with the Freedom of Information Act and 43 CFR Part 2, Subpart A and B.

6. If any Utility considers an action or omission to be an Inconsistent Act or a Breach, then that Utility may withdraw from this Accord by giving written notice of its intent to withdraw, pursuant to Paragraph 7; provided, however, that in the case of an Inconsistent Act, such notice of withdrawal may not take place until the time period to initiate administrative appeal of the Inconsistent Act has expired.
7. A withdrawing Utility initiates withdrawal by providing written notice of an Inconsistent Act or Breach and its intent to withdraw to all CAP members. This notice must include a brief statement setting forth: (A) the date and nature of the Inconsistent Act or Breach giving rise to the right to withdraw and (B) how the alleged Inconsistent Act or Breach meets the definition of "Inconsistent Act" or "Breach," as defined herein.
8. In the event of an alleged Accord Breach by any CAP member, the CAP member that is alleged to have breached the Accord shall have thirty (30) days after receipt of the notice of Breach within which to cure the Breach. If it is not reasonably possible to cure such Breach within thirty (30) days, the breaching CAP member shall notify the CAP Board ("Board," see Paragraph 26) of the time reasonably necessary to cure such Breach. If the Board can agree on the time reasonably necessary to cure the Breach, the breaching CAP member shall proceed to cure such Breach within such time as the Board shall agree. If the Board is unable to agree on the time reasonably necessary to cure the Breach, the breaching CAP member shall proceed to cure such Breach as soon as reasonably possible. The breaching CAP member(s) shall keep the Board informed of the progress in curing the Breach. Failure of the breaching CAP member to cure a Breach in accordance with this paragraph shall allow the CAP member that is harmed by the Breach to withdraw from the Accord.
9. In the event of a withdrawal by a Utility or the failure of a Utility to cure a Breach of the Accord, the Agencies have the option to reconsider any prior fish passage prescriptions submitted pursuant to FPA §18 for Projects owned by the withdrawing or breaching Utility. Withdrawal relieves the Utility of its performance obligations under this Accord, but will not result in the return of any funds previously contributed pursuant to Paragraph 37.
10. If the Accord Utility membership changes, the Plan will be adjusted by the remaining CAP members to be compatible with funding being provided by the remaining member Utilities.
11. The Agencies and Utilities agree that extension of the Plan beyond 2017 is optional, and the obligation and agreement to comply with the Accord is not conditioned upon a continuation of the Plan beyond the initial 10-year term.

12. The Agencies and the Utilities agree to use their best efforts to make this Accord a success and to participate in all Accord administrative activities at their own expense.

#### SCE&G Specific Agreements

13. The reservoir elevation limitations, required flow releases, low inflow protocols or high inflow protocols to be developed in a relicensing agreement for the Saluda Hydroelectric Project among the USFWS, SCDNR, and SCE&G along with the reservation by the USFWS of any fishway prescriptions for this Project will be filed with the FERC for the term of the new Saluda Hydroelectric Project license which is anticipated to be issued in 2010.
14. It is the understanding of the CAP that the diadromous fish study needs below the Parr Shoals Development Dam will be addressed through the Accord. Additional diadromous fish studies downstream of Parr Shoals Development Dam will not be required during the relicensing of the Parr Hydroelectric Project. A Fish Passage Feasibility Assessment (an evaluation of the upstream and downstream passage alternatives and their conceptual designs) will be conducted pursuant to the Accord, by SCE&G, and will commence upon attainment of the biological triggers as set out in Appendix B.
15. The Fish Passage Feasibility Assessment will commence at the Parr Shoals Development Dam within one year following passage of 50% of the adult anadromous American shad or adult anadromous blueback herring target restoration numbers as set out in Appendix B, upstream for any three years in a five-year period at the Columbia Diversion Dam Fish Passage Facility. Construction of a fishway at the Parr Shoals Development Dam will be initiated within one year and completed within three years following passage of 75% of the adult anadromous American shad or adult anadromous blueback herring target restoration numbers as described in Appendix B, upstream for any three years in a five-year period at the Columbia Diversion Dam Fish Passage Facility. In no event shall fish passage feasibility assessment or construction of the fishway commence before 2012. No changes will be required in the Parr Hydroelectric Project's current operations until issuance of the new FERC license for this Project. Any fish passage at this Project will not impact generation and pumping operations at the Fairfield Pumped Storage Facility until relicensing studies support the need for such a change and then only with the issuance of the new license for the Parr Hydroelectric Project (anticipated to be issued by FERC in 2020).
16. The USFWS agrees to reserve its FPA §18 authority to prescribe any type of fish passage facilities for sturgeon species at the Parr Shoals Development Dam until the new FERC license is issued for the Parr Hydroelectric Project, anticipated to be in 2020.
17. In the event that SCE&G applies for an amendment to the Parr Hydroelectric Project's current license for construction of a future power plant, the USFWS will reserve its authority under FPA §4(e) and §18 for this license amendment at that Project.
18. The Fish Passage Feasibility Assessment, including conceptual designs, will begin at the Neal Shoals Hydroelectric Project within one year following 50% of target restoration

numbers for adult anadromous American shad or adult anadromous blueback herring, as described in Appendix B, being passed upstream for any three years out of a five-year period at the Parr Shoals Dam. The construction of fish passage facilities at the Neal Shoals Hydroelectric Project will commence within one year and be completed within three years following passage of 75% of target restoration numbers of adult anadromous American shad or adult anadromous blueback herring being passed upstream three years out of a five-year period at the Parr Shoals Development Dam, but in no event shall the fish passage feasibility assessment or construction commence before 2016.

#### Duke Specific Agreements

19. For the Catawba-Wateree Hydroelectric Project, the obligation to operate a fishway and associated facilities as set out in the Accord will continue for the term of the new license, and the USFWS agrees that the prescription to be filed with the FERC for the new license will include such a provision. A trap and truck fish passage facility ("T&T facility") for adult anadromous American shad and adult anadromous blueback herring will be designed by Duke, in consultation with the Agencies and with input from the Accord Technical Committee ("TC;" see Paragraph 33), by December 31, 2015, and will commence operation by January 1, 2018, at the Wateree Development of the Catawba-Wateree Hydroelectric Project (see Appendix B). Fish trapped at this T&T facility will be placed in Lake Wateree. The year after the combined annual total catches of adult anadromous American shad and adult anadromous blueback herring equal or exceed 10,000, and in all subsequent years of the term of this Accord, all trapped adult anadromous American shad and adult anadromous blueback herring shall be trucked to upstream areas in the SC portion of the Catawba-Wateree River Basin designated by the TC. If the Accord is not functional, then the USFWS and the SCDNR will designate these upstream reaches in the SC portion of the Catawba-Wateree River Basin by consensus. Effectiveness studies (e.g., usefulness of attraction flows to increase capture of target fish and determination of target fish mortality associated with handling and transportation) for this T&T facility will be conducted by Duke during the first three years of operations, provided sufficient numbers of fish, as determined by the consensus of the Agencies with input from the TC, are available to do so. Information from the effectiveness studies will be used to improve effectiveness of the T&T facility.
20. The Agencies agree that operation of the T&T facility at the Wateree Development, as specified above and as incorporated in the prescription to be filed with the FERC for inclusion in the new license, will fulfill FPA §18 prescriptions and ESA §7 requirements for upstream passage for all adult anadromous fish (including but not limited to American shad, blueback herring, Atlantic sturgeon, and shortnose sturgeon) for all Catawba-Wateree Hydroelectric Project developments for the term of the new license.
21. The SCDNR will issue a scientific collection permit to operate the T&T facility at the Wateree Development pursuant to SC Code §50-11-1180 to ensure that Duke will not be held civilly or criminally responsible for any bycatch mortality, provided Duke is in compliance with its collection permit.

22. The Agencies agree that existing upstream fish passage facilities at the Wateree Development (i.e., partial ramp(s) and manual trap(s) in good repair and similar to that described in David Solomon's 2004 Fish Passage Design for Eels and Elvers) that use manual transport and release of captured American eels into Lake Wateree are sufficient to fulfill FPA §18 upstream prescriptions for catadromous fish (e.g., American eels) at the Wateree Development, when supplemented with additional partial ramp(s)/manual trap(s) determined by the results of partial ramp/manual trapping conducted in all seasons in 2009-2011 in areas adjacent to the spillway (data collected via the Catawba-Wateree River Elver Study in Appendix A). So long as American eels are passed upstream at the Wateree Development in an efficient, safe, and timely manner, Duke, at its sole discretion, may decide to continue operation of the ramp/trap fishway or construct a new passage facility. If Duke chooses to construct a new American eel passage facility at the Wateree Development, Duke will consult with the Agencies and the TC regarding facility design and construction.
23. The Agencies and Duke agree that a series of portable ramp/trap devices will be sufficient for the three-year monitoring studies, and that the studies will be conducted at each development in an orderly upstream sequence of the Catawba-Wateree Hydroelectric Project developments upstream of the Wateree Development. A template for the initial and subsequent studies to ascertain American eel abundance at each tailrace site is set out in the 10-Year Action Plan and is budgeted in Appendix A (location of such studies will occur in an orderly upstream sequence beginning at the Rocky Creek-Cedar Creek Development and ending at the Bridgewater Development at a time to be determined in consultation with the Agencies and with input from the TC). These data will allow effective design and placement of permanent or semi-permanent passage devices for best upstream passage at each development for American eels. Duke will develop a study plan for review and approval by the Agencies with input from the TC prior to commencing any studies at these upstream developments. Information collected from these studies shall include size, seasonality, and location of juvenile American eels in the tailrace areas where these fish may congregate. Captured American eels will be passed into the immediate upstream reservoir. The Agencies and the TC may approve a request for extension of the term of the initial monitoring study in the event few American eels are captured during the study phase.
24. Following the above monitoring for American eels described in Paragraph 23, Duke agrees to design, construct, and operate at each development (in consultation with the Agencies and with input from the TC after a review of the data collected during each three-year study) permanent or semi-permanent upstream passage facilities at each development within two years of completion of the monitoring study at a particular development. So long as American eels are passed upstream at each development in an efficient, safe, and timely manner, Duke, at its sole discretion, may decide to continue operation of the ramp/trap type fishways or construct a new passage facility at each Catawba-Wateree Project development.
25. Duke in cooperation with Agencies and with input from the TC will commence studies in 2024 to address the safe, timely, and effective downstream passage of American eels in the Catawba-Wateree system.

## **Management and Direction**

### **CAP Board**

26. The Accord will be directed by a Board composed of one representative appointed by each CAP member. Each CAP member may designate an alternate who may function as its Board representative in the absence of the appointed Board member. It shall be the responsibility of each CAP member to notify other members in writing within 14 calendar days following any change of the name or contact information for its Board member and/or alternate. On an annual basis, the Board shall elect a chairperson ("Chair") and may elect other officers as deemed necessary. Initial terms for Board members will be staggered so that there is continuity in the operation of the Accord over the long term, with Duke and USFWS Board members serving three-year initial terms and SCE&G and state agency members serving two-year terms. Successive Board members will serve two-year terms. Meetings by the Board will be held in compliance with the Freedom of Information Act in the jurisdiction where the meeting is held.
27. The initial Board shall establish and schedule at least one meeting of the Board per calendar year (Annual Meeting) for the duration of the Accord. The Chair will select the meeting location and will develop an agenda and provide draft minutes of the previous meeting within two weeks following each meeting and require all members to return their comments within two weeks following receipt of the draft minutes. Additional meetings (Called Meetings) of the Board may be called by the Chair or upon the agreement of at least 25 percent of the Board members, but no Called Meeting that is not called by consensus vote by the Board may be held with less than four weeks prior written notice.
28. A quorum is required for the transaction of business (e.g., official votes) at any Board meeting. A quorum is defined as the presence of a representative or alternate of each CAP member participating in the Accord on the date of the meeting. Once a quorum is established, it may not be broken by departure of one or more members' representatives or alternates, and voting may occur once a quorum is established.
29. Failure to comply with terms of the Accord, including the prompt payment of a Utility's annual contributions, will result in the revocation of that member's right to vote until the failure to comply is remedied.
30. The representatives of the members, or their alternates, may participate, which participation includes voting, in meetings by any means of communication by which all participants may simultaneously hear each other during the meeting. A member's representative or its alternate participating in a meeting by this means is deemed to be present in person at the meeting. No proxy voting shall be permitted. A member's alternate shall not vote if that member's regular representative is present.
31. In addition to conducting its affairs at meetings, the Board may also validly exercise its authority in writing. A proposal may be presented, whether in written or electronic format, to each member's representative. Upon the approval, whether in written or electronic format, of each member's representative to that written proposal, the action of

the Board concerning the proposal will constitute a valid exercise of the Board's authority. A complete record of all action taken by the Board without meeting shall be filed with the minutes of the proceedings of the members, whether done before or after the action so taken.

32. Final decisions must be made by consensus of Board members or their alternates.

### **Technical Committee (TC)**

33. A TC comprised of fishery biologists and/or other qualified professionals representing each CAP member will be established by the Board and will advise the Board on technical issues associated with the Accord. The TC will exist for the duration of the Accord.

34. The TC will develop consensus recommendations to the Board and will guide the design and implementation of all Plan tasks for the duration of the Plan. Following the expiration of the term of the Plan, the TC will function as a scientific advisor to the Board regarding all matters related to the restoration of diadromous fish in the Santee Basin.

35. Failure to allocate and disburse funds according to direction of the Board will result in the revocation of that member's right to participate or to vote on matters brought to the TC, until the failure to comply is remedied.

36. For the duration of the Accord, the TC will provide a brief written annual progress report to the Board by February 15 of the following year.

### **Communications Protocol**

The Board will develop a protocol to communicate clearly on all Accord-related resource study, protection, restoration, and enhancement activities occurring in the Basin. All CAP members shall adhere to the Communications Protocol. It is the intent of the Accord to publicly disseminate all technical and scientific findings of its monitoring and study efforts.

### **Term of the Accord and the 10-year Action Plan**

The effective date of this Accord shall be April 15, 2008. The Accord shall terminate for SCE&G at the end of the term of the new FERC license for the Saluda Hydroelectric Project (expected to be issued by the FERC in 2010) and for Duke at the end of the term of the new FERC license for the Catawba-Wateree Hydroelectric Project (expected to be issued in 2009). Each annual extension, if any, of the applicable new licenses by the FERC (commonly referred to as an "annual license") will also extend the term of the Accord for the applicable Utility by one year. Since diadromous fish restoration can be a long-term endeavor, the Board may desire to extend the term of the Plan, or to increase funding during its term. Through a consensus vote of its members, the Board may alter or modify Plan tasks and expenditures within those amounts currently established by the Plan and such Plan modifications do not require new signatures on the Accord from the authorized representative of each CAP member's organization.

The term of the Plan shall be April 15, 2008, through December 31, 2017, unless extended as noted above. The Board shall consider revision or renewal of the Plan in 2015 and shall decide by consensus of its membership if the Plan shall be revised or renewed. A decision not to extend or renew the Plan does not affect the obligations of and agreements among the CAP members contained in the Accord.

### **Dispute Resolution**

Major disputes regarding the Accord, if at all possible, will be resolved by the Board through good-faith negotiations which may be assisted by selecting the services of a neutral mediator (cost of the mediator to be shared as determined by the Board).

### **Roles and Responsibilities for Implementing the 10-year Action Plan**

#### **Utilities**

37. Utilities will fund the Plan with SCE&G providing \$200,000 per year (unadjusted annual contribution) and Duke providing \$500,000 per year (contributions expressed in 2008 dollars and to be adjusted annually using the Consumer Price Index). Additional funding secured through grants or other sources by the CAP may be incorporated into the budget and is encouraged. Funding levels provided by the original Utilities are set at that described above. If the costs of proposed activities and studies under the Plan exceed the funding provided by the Utilities, then later activities and studies under the Plan will be abandoned or reduced appropriately as determined by the Board to accommodate the funding level agreed to in this document, unless the necessary additional funding can be obtained by new utility participants, non-CAP member entities, grants and/or existing Fisheries Enhancement Plans from within the Basin. However, funding by non-CAP members will not render otherwise ineligible entities eligible to guide Accord activities or become members of the CAP.
38. In addition to the funding set forth in Paragraph 37, Utilities will provide technical/scientific input to program development, personnel and in-kind services (as appropriate), while conducting some studies, and will provide assistance in the scheduling and conduct of studies.

#### **State and Federal Agencies**

39. Agencies will provide technical/scientific input to program development, assistance in the scheduling of studies, personnel and in-kind services (as appropriate) while conducting some studies, and assistance in reporting study results.
40. Agencies will investigate and solicit any sources of supplemental or matching funds.
41. Agencies will assist, to the extent practicable, with the issuance of all applicable permits.

## **Fund Management**

Funds to be contributed by the Utilities shall be maintained by each Utility and accounted for in a separate CAP Fund Account. The CAP Board will develop and adopt procedures concerning when the Utilities will deposit their contributions to this account and how disbursements from this account are approved. Each Utility shall provide annually, no later than March 31, a report of all fund deposits, disbursements, and balances for the previous calendar year. Any funds obtained by a Utility from other sources that are to be used solely in the execution of the Plan shall be included in that Utility's CAP Fund Account and shall be identified in the annual report as a contribution by others. The annual reports provided by the Utilities to the CAP Board will be provided to all CAP members. All such funds, whether contributed by Utilities or others shall be the exclusive property of the CAP to be disbursed and spent according to the Board.

Disbursements from a Utility's CAP Fund Account shall be made only at the consensus direction of the CAP Board. Each Utility owes a fiduciary duty to manage and account for the funds for the benefit of the CAP and to follow the CAP Board's direction for disbursements.

It is the desire of the Utilities that all monies contributed to the Plan be spent during the term of the Plan. In the event that the Plan is not extended and unspent funds are available at the conclusion of the Plan term, the Board will decide by consensus and direct the Utilities to allocate these monies to other ongoing programs of a similar nature and the Utility CAP Fund Accounts will be closed, after which each Utility shall submit to the CAP Board a final accounting report within 60 days following closing its account.

## **Reserved Authority**

The Utilities recognize that the USFWS will reserve authority to alter its FPA §4(e) conditions and FPA §18 prescriptions for diadromous fish. The Agencies and Utilities agree that the Accord provisions are appropriately based on current knowledge of diadromous fisheries in the Santee River Basin. The USFWS believes it will be able to meet its FPA §§ 4(e) and 18 and ESA §7 obligations consistent with its Accord commitments.

## **State Commitments**

The SCDNR agrees to use its best efforts to make this Accord a success. In the event that the USFWS exercises its reserved authority and issues a FPA §18 prescription or a FPA §4(e) condition, or an ESA §7 requirement, or the SCDHEC issues a CWA §401 certification that is inconsistent with, or would impose obligations in addition to those set forth in the Accord or Project settlement agreement with the SCDNR, the SCDNR may exercise any procedural and substantive rights it may have to contest such a prescription, condition, or requirement.

The NCWRC agrees to use its best efforts to make this Accord a success. In the event that the USFWS exercises its reserved authority and issues a FPA §18 prescription or a FPA §4(e) condition, or an ESA §7 requirement, or the North Carolina Division of Water Quality issues a CWA §401 certification that is inconsistent with, or would impose obligations in addition to those set forth in the Accord or Project settlement agreements with the NCWRC, the NCWRC may exercise any procedural and substantive rights it may have to contest such a prescription, condition, or requirement.

## **Modification of the Accord**

This Accord may be modified; however, except for modifications of the Plan as described above, no modification of the Accord will be effective or valid unless it is signed by the authorized representative of each CAP member's organization.

## **Miscellaneous Agreements**

No Admission of Liability – The Accord is a compromise, balancing many interests. The actions taken hereunder are not intended nor shall be construed as an admission on the part of any CAP member, or its agents, representatives, attorneys or employees that such CAP member was so obligated in any manner independent of this Accord. Except as provided herein, no CAP member shall be prejudiced, prevented, or estopped from advocating in any manner or before any entity, including the FERC or any state agency, any position inconsistent with those contained in this Accord regarding the licensing, permitting and license compliance of these or any other hydropower projects other than those addressed in this Accord.

Accord Terms Contractual/Merger – The terms of the Accord are contractual and not mere recitals. This Accord, which includes and fully incorporates any and all Appendices and the Plan, constitutes the entire agreement among the CAP members with respect to the subject matter hereof. All prior contemporaneous or other oral or written statements, representations or agreements by, between or among any of the CAP members, with respect solely to fish passage and fishway prescriptions of the subject Projects are superseded hereby. Nothing herein shall be construed to affect, negate, or supersede obligations and benefits arising from Duke's Comprehensive Relicensing Agreement and SCE&G's potential settlement agreement for the Saluda Hydroelectric Project regarding reservoir elevation limitations, required flow releases, low inflow protocols or high inflow protocols.

Enforceability – All terms of the Accord not incorporated as FERC License Articles shall be enforced through remedies available under applicable state or federal law.

Compliance with Laws – It is the responsibility of the CAP members to comply with all applicable federal, state and local laws, codes, rules, regulations, and orders of any governmental authority, and, except as otherwise provided herein, each CAP member will obtain, at its own expense all permits and licenses pertaining to its obligations under the Accord. The Accord is not intended and shall not be construed as a defense to or a limitation on civil or criminal liability in any action brought by any governmental entity to enforce any law and shall not limit the assessment or award of any fees, fines, penalties, remediation costs or similar liabilities in any such enforcement action.

Force Majeure – The Parties agree that a CAP member shall not be in breach of the Accord to the extent that any delay or default in performance is due to causes beyond the reasonable control of the delayed or defaulting CAP member; provided, that the delayed or defaulting CAP member notifies the other CAP members as soon as possible of: (A) the event; (B) the expected duration of the event; and (C) the delayed or defaulting CAP member's plan to mitigate the effects of the delay or default. Such causes may include, but are not limited to, natural disasters, labor or civil disruption, acts of terrorism, the inability to secure any legal authorization from another entity

(e.g., a permit or license) where such legal authorization is a prerequisite or requirement for complying with the Accord, or breakdown or failure of the affected Project's works, so long as such causes are beyond the reasonable control of the delayed or defaulting CAP member.

Applicable Law and Venue – This Accord shall be governed by the law of the state wherein the subject hydroelectric development is located. Execution of the Accord does not constitute a consent to jurisdiction of any court unless such jurisdiction otherwise exists. Execution of the Accord also does not constitute a waiver of any immunity or privilege except as provided by law.

Waiver Independence – No consent to or waiver of any provision of the Accord shall be deemed either a consent to or waiver of any other provision hereof, whether or not similar, or a continuing consent or waiver unless otherwise specifically provided.

Water Rights Unaffected – Except as between the Parties hereto and as specifically set forth in this Accord, the Accord does not release, deny, grant or affirm any property right, license or privilege in any waters or any right of use in any waters. The Accord does not authorize any person to interfere with the riparian rights, littoral rights or water use rights of any other person. No person shall interpose the Accord as a defense in an action respecting the determination of riparian or littoral rights or other water use rights.

Parties' Own Costs – Except as expressly provided for in the Accord, all CAP members are to bear their own costs of participating in the Accord.

Existing Laws – Unless otherwise noted, any reference to any statute, regulation or other document refers to the statute, regulation or document as it exists on the date of the first signature on the Accord.

No Third-Party Beneficiary – The Accord shall not create any right in any individual or entity that is not a signatory hereto or in the public as a third-party beneficiary. This Accord shall not be construed to authorize any such third party to initiate or to maintain a suit in law or equity or other administrative proceeding.

No Commitment of Funds – Nothing in the Accord shall be construed as obligating any federal, tribal, state, or local agency to expend in any fiscal year any sum in excess of appropriations made by Congress, tribal councils, or state or local legislatures or administratively allocated for the purpose of this Accord for the fiscal year or to involve any federal, tribal, state, or local agency in any contract or obligations for the future expenditure of money in excess of such appropriations or allocations.

No Government Agency Delegation – Nothing in the Accord shall be construed as requiring or involving the delegation by any government agency to any other body of any authority entrusted to it by Congress, tribal council, or by the legislature of any state.

Successors and Assigns – The Accord shall apply to, and be binding on, the CAP members, their successors, transferees and assigns. No change of ownership in a Project or transfer of a license shall in any way modify or otherwise affect any other CAP member's interests, rights, responsibilities, or obligations under the Accord. (See the General section of the Accord for a list of Projects and current licensees.) Unless prohibited by applicable law, the licensee of the

affected Project shall provide in any transfer of the existing or new license for the Project, that such new owner shall be bound by, and shall assume the rights and obligations of the Accord upon completion of the change of ownership. In the event applicable law prohibits the new owner from assuming the rights and obligations of the Accord, any CAP member may withdraw from the Accord. The licensee of the affected Project shall provide written notice to the other CAP members at least 90 days prior to completing such transfer of the license.

Caption Headings – The paragraph titles and caption headings in the Accord are for convenience of reference and organization, are not part of the Accord, and shall not be used to modify, explain, interpret, or define any provisions of the Accord or the intention of the CAP members.

Limitation of Applicability – The CAP members have entered into the negotiations and discussions leading to the Accord with the explicit understanding that all discussions relating thereto are to be considered as settlement negotiations, shall not prejudice the position of any CAP member or entity that took part in such discussions and negotiations, and are not to be otherwise used in any manner in connection with these or any other proceedings. The CAP members understand and agree that execution of the Accord establishes no precedents, does not admit or consent to any fact, opinion, approach, methodology, or principle except as expressly provided herein.

Execution in Counterparts – This Accord may be signed in counterparts to expedite signatures, and shall become binding between the Utilities and the Agencies upon the last signature below by an authorized representative of each.

Full Legal Authority – Each signatory Party to the Accord represents that it has the full legal authority to execute this Accord and to bind the principal who it represents, and that by such representative's signature, such principal shall be bound upon full execution of the Accord.

Notices – Notices in connection with matters under the Accord shall be provided in writing and addressed to:

Hugh Barwick  
Senior Environmental Resource Manager  
Duke Energy Carolinas, LLC  
526 South Church Street, P. O. Box 1006 (EC12Y)  
Charlotte, NC 28201-1006  
704/382-8614 FAX

William Argentieri, PE  
Manager—Civil Engineering F/H Technical Services  
South Carolina Electric & Gas Company  
111 Research Drive  
Columbia, SC 29203  
803/933-7849 FAX

Bennett Wynne  
Anadromous Fish Coordinator  
NC Wildlife Resources Commission  
901 Laroque Avenue  
Kinston, NC 28501  
252/522-9736 FAX

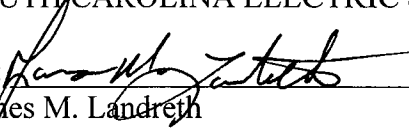
Richard Christie  
FERC Coordinator  
SC Department of Natural Resources  
1771-C Highway 521 By-Pass South  
Lancaster, SC 29720  
803/286-5598 FAX

Tim Hall  
USFWS Field Supervisor  
176 Croghan Spur Rd., Suite 200  
Charleston, SC 29407  
843/727-4218 FAX

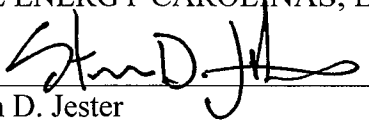
Brian Cole  
USFWS Field Supervisor  
160 Zillicoa Street  
Asheville, NC 28801  
828/258-5330 FAX

AGREED TO BY THE AUTHORIZED REPRESENTATIVES OF THE PARTIES NAMED  
BELOW ON THE DATES SHOWN BY THEIR SIGNATURES:

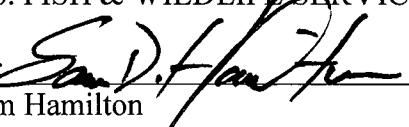
SOUTH CAROLINA ELECTRIC & GAS COMPANY

By:  Date: 4/18/08  
James M. Landreth  
Vice President, Fossil Hydro Operations  
111 Research Drive  
Columbia, SC 29203

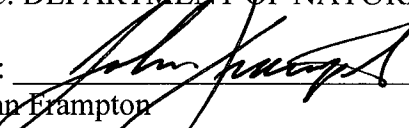
DUKE ENERGY CAROLINAS, LLC

By:  Date: 4/10/08  
Steven D. Jester  
Vice President, Hydro Licensing and Lake Services  
526 South Church Street  
Charlotte, NC 28202

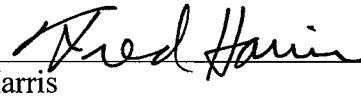
U.S. FISH & WILDLIFE SERVICE

By:  Date: 4/25/08  
Sam Hamilton  
Regional Director, Southeast Region  
1875 Century Blvd., Suite 400  
Atlanta, GA 30345

S.C. DEPARTMENT OF NATURAL RESOURCES

By:  Date: 5/14/08  
John Frampton  
Director  
1000 Assembly Street  
Columbia, SC 29202

N.C. WILDLIFE RESOURCES COMMISSION

By:  Date: 4/21/08  
Fred Harris  
Interim Executive Director  
1701 Mail Service Center  
Raleigh, NC 27699-1701

**Appendix A. Projected annual costs for tasks in the Santee River Basin Cooperative Fish Passage Accord 10-Year Action Plan<sup>1</sup>.**

Task	Years										Total for all years
	2008	2009	2010	2011	2012	2013	2014	2015	2016	2017	
Hatchery Operations	\$ 340,000	\$ 138,000	\$ 142,000	\$ 146,000	\$ 151,000	\$ 155,000	\$ 160,000	\$ 165,000	\$ 170,000	\$ 175,000	\$ 1,742,000
Adult Shad Transport	\$ 77,000	\$ 80,000	\$ 82,000	\$ 84,000	\$ 87,000	\$ 90,000	\$ 92,000	\$ 95,000	\$ 98,000	\$ 101,000	\$ 886,000
Elver Studies/Catawba- Wateree River	\$ 43,000	\$ 64,000	\$ 46,000	\$ 47,000	\$ 75,000	\$ 50,000	\$ 52,000	\$ 82,000	\$ 55,000	\$ 56,000	\$ 570,000
Juvenile Shad Monitoring		\$ 106,000	\$ 109,000	\$ 113,000	\$ 116,000	\$ 119,000	\$ 123,000	\$ 127,000	\$ 130,000	\$ 134,000	\$ 1,077,000
Adult Shad Migration		\$ 159,000						\$ 190,000			\$ 349,000
Sturgeon Studies			\$ 109,000	\$ 113,000	\$ 116,000	\$ 119,000	\$ 123,000				\$ 580,000
Elver Studies/Parr									\$ 65,000	\$ 34,000	\$ 99,000
Estimated Annual Costs	\$ 460,000	\$ 547,000	\$ 488,000	\$ 503,000	\$ 545,000	\$ 533,000	\$ 550,000	\$ 659,000	\$ 518,000	\$ 500,000	\$ 5,303,000
Available Funds	\$ 700,000	\$ 715,000	\$ 730,450	\$ 746,364	\$ 762,755	\$ 779,638	\$ 797,027	\$ 814,938	\$ 833,386	\$ 852,388	\$ 7,731,946
Fund Balance <sup>2</sup>	\$ 240,000	\$ 408,000	\$ 650,450	\$ 893,814	\$ 1,111,569	\$ 1,358,207	\$ 1,605,234	\$ 1,761,172	\$ 2,076,558	\$ 2,428,946	

<sup>1</sup> Assumes an annual 3% inflation rate for all items except contributions by South Carolina Electric and Gas Company.

<sup>2</sup> Fund balance or contingency is the difference between the estimated task costs and available funds for that year, and includes the balance from the previous year.

Appendix B. No-sooner-than dates, total restoration numbers, and biological triggers for construction of fish passage facilities at selected Santee River Basin hydroelectric dams.

Utility	Dam	Date	Total number <sup>1</sup>	50% Trigger <sup>2</sup>	75% Trigger <sup>3</sup>
SCE&G	Saluda	Deferred	NA <sup>4</sup>	NA	NA
	Columbia <sup>5</sup>	2007	92,800 (464,000)	46,400 (185,600)	69,600 (348,000)
	Parr	2012	128,150 (640,750)	64,075 (320,325)	96,112 (480,562)
	Neal Shoals	2016	37,400 (187,000)	18,700 (93,500)	28,050 (140,250)
Duke	Wateree <sup>6</sup>	2018	NA	NA	NA

<sup>1</sup> Total restoration numbers for adult anadromous American shad (blueback herring) developed by the USFWS from surface acreage calculations of the river (including available tributaries) from that dam to the next dam upstream.

<sup>2</sup> 50% trigger or when 50% of the total restoration numbers for adult anadromous American shad (blueback herring) for the unblocked reach upstream of the dam are being passed at that dam. This would initiate a Fish Passage Feasibility Assessment at the upstream dam.

<sup>3</sup> 75% trigger or when 75% of the total restoration numbers for adult anadromous American shad (blueback herring) for the unblocked reach upstream of the dam are being passed at that dam. This would initiate construction of a Fish Passage Facility at the upstream dam.

<sup>4</sup> NA = Not applicable

<sup>5</sup> Volitional Fish Passage Facility is operational and passage is currently being evaluated.

<sup>6</sup> Trap and Truck Fish Passage Facility operational by January 1, 2018.

**Appendix C. River miles, surface acreages of the mainstem river and associated tributaries, and restoration numbers (fish/acre) calculated for adult anadromous American shad and blueback herring from selected reaches of the Broad River.**

Restoration phase and Reach	River miles	Mainstem acres	Tributary acres	Total acres	Shad <sup>1</sup>	Herring <sup>2</sup>
<b>Phase 1</b>						
Columbia Dam to Parr Shoals Development Dam	24	1,758	98	1,856	92,800	464,000
<b>Phase 2</b>						
Parr Shoals Development Dam to Neal Shoals Dam	31	2,106	457	2,563	128,150	640,750

<sup>1</sup> American shad restoration numbers are the product of total acres and 50 fish/acre.

<sup>2</sup> Blueback herring restoration numbers are the product of total acres and 250 fish/acre.

**APPENDIX E**  
**REFERENCED CORRESPONDENCE**

# Letter 2



## United States Department of the Interior

FISH AND WILDLIFE SERVICE  
176 Croghan Spur Road, Suite 200  
Charleston, South Carolina 29407



## UNITED STATES DEPARTMENT OF COMMERCE National Oceanic and Atmospheric Administration NATIONAL MARINE FISHERIES SERVICE

May 30, 2003

Mr. Mark Oakley  
Relicensing Project Manager  
Catawba-Wataree Hydroelectric Project  
P.O. Box 1006  
Mail Code EC12H  
526 South Church Street  
Charlotte, North Carolina 28201

RE: First Stage Consultation Comments and Request for Studies, Catawba-Wataree  
Hydroelectric Project (FERC Project No. 2232), North Carolina and South Carolina.

Dear Mr. Oakley:

The U.S. Fish and Wildlife Service and NOAA Fisheries (Services) have reviewed the February 7, 2003, Initial Stage Consultation Document (ICD) for the Catawba-Wataree Project (P-2232). This document is our combined response to the ICD and identifies information needs and study requests. This response has been coordinated among the U.S. Fish and Wildlife Service field offices in Charleston, South Carolina and Asheville, North Carolina and NOAA Fisheries. **These comments are submitted in accordance with the provisions of the Fish and Wildlife Coordination Act, as amended (16 U.S.C. §§ 661-667e); Section 7 of the Endangered Species Act of 1973, as amended (16 U.S.C. §§ 1531-1543); the Federal Power Act (16 U.S.C. § 791 et seq.); the Migratory Bird Treaty Act (16 U.S.C. §§ 1536, 1538); the National Environmental Policy Act (42 U.S.C. § 4321 et seq.); the Clean Water Act (33 U.S.C. § 1251 et seq.); and the Electric Consumers Protection Act of 1986 (Pub. L. No. 99-495, 100 Stat. 1243).**

### **The Catawba-Wataree Project**

The Catawba-Wataree Project is comprised of thirteen hydropower plants and eleven reservoirs. The Project spans over 200 miles of river and encompasses approximately 1,700 miles of shoreline within nine counties in North Carolina (Alexander, Burke, Caldwell, Catawba, Gaston, Iredell, Lincoln, McDowell, and Mecklenburg) and five counties in South Carolina (Chester, Fairfield, Kershaw, Lancaster, and York). The Project consists of the Bridgewater, Rhodhiss, Oxford, Lookout Shoals, Cowans Ford, and Mountain Island Developments in North Carolina, and Wylie, Fishing

Creek, Great Falls-Dearborn, Rocky Creek-Cedar Creek, and Wateree Developments in South Carolina. The Catawba River originates in the Blue Ridge Mountains in North Carolina and flows south to its confluence with the Big Wateree Creek and forms the Wateree River in South Carolina. The Wateree River flows to its confluence with the Congaree River and forms the Santee River which flows to the Atlantic Ocean. The Santee River is impounded at river mile 87 by the Santee-Cooper Hydroelectric Project. The Catawba-Wateree Project's total drainage area as measured at the Wateree Development is 4,750 square miles.

Project reservoirs support warm water fisheries, and reservoir shorelines provide important foraging, nesting and other habitat for terrestrial wildlife and migratory birds. Reservoir tailwaters support cold-, cool-, and warm-water fisheries. The aquatic and terrestrial wildlife that live within the Project's boundaries are dependent upon the shoreline and permanent source of water for aquatic habitat. The Services are very interested in ensuring that the Project is managed in a way that protects fish and wildlife resources.

### **Project History**

The Catawba-Wateree Hydroelectric Project has effectively impeded and fragmented approximately 220 miles of flowing river. Historically, anadromous fish migrated upstream to the Piedmont region of the Catawba River and some continued into North Carolina. Today diadromous fish spawning migrations are impeded at the Wateree Dam, the furthest downstream dam within the project. In addition, many miles of riffle/shoal habitat, important not only for anadromous fish spawning but also for riverine fish habitat, have been affected by impoundments and diversions. Accordingly, there are several existing reaches within the project that are of particular importance to the Services due to their potential for habitat restoration. These areas include the 35 miles of free flowing river below the Bridgewater Development, the 39 miles of free flowing river below Lake Wylie, the dewatered Great Falls bypass, the 76 miles of free flowing river below the Wateree Dam, as well as the major tributaries of the system. The Services believe there is potential for restoration and enhancements within these areas that would greatly benefit diadromous fish, resident fish, and terrestrial and avian wildlife.

### **Fish and Wildlife Service Management Goals**

The Services' general management goals and objectives for the Catawba and Wateree Rivers, are to protect and enhance a balanced, diverse fish community and the diversity of aquatic habitats on which that community depends, as well as to provide safe and effective upstream and downstream passage and habitat for diadromous and migratory game and non-game fish species. Further goals include the recovery of diadromous fish populations of the Santee-Cooper Basin (which includes the Catawba-Wateree sub-basin) to levels that provide economic, social and ecological values and the protection and recovery of endangered species. An Interagency Santee-Cooper Basin Diadromous Fish Passage and Restoration Plan which identifies these resource goals has been accepted by the FERC as a Comprehensive Plan under Section 10(a)(2)(a) of the Federal Power Act and FERC Order No. 481-A. The Catawba-Wateree Hydroelectric Project and other hydroelectric projects have

disproportionately eliminated and cumulatively affected riffle and shoal habitats in the Catawba-Wataree River watershed. Therefore, restoration, protection and/or enhancement of certain habitats types (i.e., riffles and shoals) is a priority goal for the Fish and Wildlife Service. Identification of opportunities for the protection and enhancement of valuable wildlife habitat and enhancing potential use of public trust waters for recreation are additional resource goals of the Fish and Wildlife Service. The Fish and Wildlife Service is of the view that a licensee should be responsible for the management costs associated with the protection and utilization of the public trust resources it utilizes.

The studies recommended below will allow the Fish and Wildlife Service to gather necessary information to foster the above goals.

**NOAA Fisheries= Resource Management Goals and Objectives for Diadromous Fish Affected by the Project.**

NOAA Fisheries= primary and general goal, with respect to the relicensing of the Project and fishery resources of the Wataree-Catawba Basin, is to promote protection, management, and restoration of self sustaining diadromous fish populations to fully utilize available habitat and production capability, to restore species diversity, and to sustain viable fisheries. Diadromous species of special interest include but are not limited to American shad, river herring and other alosids, striped bass, American eel, Atlantic sturgeon, and the federally listed endangered shortnose sturgeon. Although unquantified in economic terms, the forage base provided by shad and other alosid species supports (or limits, if depressed in numbers) extremely valuable marine commercial and recreational fisheries of the Atlantic coast.

The specific goals include the following:

- ☐ *Conserve Species.* Avoid further declines and/or extinction and foster long-term survival and recovery of Santee-Wataree-Catawba Basin American shad, river herring, striped bass, American eel, Atlantic sturgeon, and shortnose sturgeon.
- ☐ *Conserve Riverine, Estuarine, and Marine Ecosystems.* Conserve the riverine ecosystem and the vital link to marine ecosystem health provided by diadromous species.
- ☐ *Balance the Life Cycle Needs of Other Species.* Ensure that diadromous fish conservation measures are balanced with the management and conservation needs of other native fish and wildlife species.
- ☐ *Support Sustainable Recreational and Commercial Fisheries.* Provide for adequate fish passage and access to essential habitats to support a sustainable shad and herring fishery, and the contribution of alosid species to sustainable fisheries for other species and to a healthy estuarine and marine ecosystem.

## **Recommended Studies and Informational Needs for Relicensing**

### **5. Passage of Diadromous Fish**

Quantify diadromous fish utilization of the Wateree River below Wateree Dam utilizing standard fish sampling gear (e.g., electrofishing, gill nets, etc.). The most effective and efficient methods of sampling should be determined in consultation with the state and Federal natural resource agencies.

Justification. The Wateree River contains 76 miles of free-flowing river below the Wateree Dam to its confluence with the Congaree River. Historically, anadromous fish migrated up the Wateree River to the Piedmont reaches of the Catawba River. The project has blocked and fragmented historical migration patterns for all diadromous species including American shad, blueback herring, striped bass, American eel, and shortnose sturgeon. The shortnose sturgeon is a federally listed endangered species and all federal agencies (including the FERC) are responsible for undertaking actions toward its recovery under Section 7(a)(1) of the Endangered Species Act (16 U.S.C. 1531-1543). This study will aid in the determination of the need for a fish passage facility at Wateree Dam.

### **6. Basin Wide Fish Passage Feasibility Study**

Determine the feasibility including the design, location, and engineering considerations and constraints of installation of an upstream and/or downstream fish passage facility at each hydropower development within the project.

Justification. Diadromous and potamodromous fish populations within the Santee-Cooper Basin, including the Catawba-Wateree sub-basin have significantly declined within the last century. There are Federal Interstate Fishery Management Plans which outline mechanisms of recovery, including fish passage at hydroelectric facilities. Diadromous species historically migrated up the Wateree River to the Catawba River but have been blocked and fragmented by the series of dams and reservoirs which constitutes the project. This study will determine the feasibility of fish passage facilities throughout the project to provide fish access to their historic spawning habitats.

### **7. Comprehensive Basin Wide Habitat Assessment**

Provide quantitative and qualitative data in GIS format of the available and potential spawning, rearing and foraging habitats (i.e., riffles/shoals, open water habitat, shallow cove areas) throughout the project, including tributaries for diadromous and resident fish species.

Justification. Information is needed on the existing available diadromous and resident fishery spawning, rearing, and foraging habitat and candidate areas for restoration throughout the project. This information will aid in the assessment of project impacts on aquatic

resources, determination of the need for fish passage, possible development of fish species target numbers, potential habitat restoration areas, and alternative mitigation alternatives.

## **8. Aquatic Habitat Fragmentation Study**

The Services request a study to describe the characteristics and extent of habitat fragmentation of aquatic communities in the Catawba-Wataree system. This study would identify isolated and fragmented populations and aquatic communities. It would evaluate the fragmentation effects of dams and reservoirs at the Project. Similar studies have been conducted at other large projects, and have been useful in understanding the relative role of the project in the continued aquatic fragmentation of river systems, as well as potential mitigative measures.

Previous studies on other projects have modeled the system to determine what portion of the watershed was being separated or Adelineked from the rest of watershed. As part of its study, the applicant should conduct a literature review to determine the characteristics of the watershed, as well as the distribution of species and patterns of aquatic communities in the Catawba-Wataree watershed.

As a first step, the applicant could examine historical fish and mussel collections to determine where species have been extirpated or exist only in low numbers. A diadromous fish species review could begin by examining historic literature in local libraries and newspapers, as well as legal records.

The Stream Habitat Fragmentation Evaluation should identify present-day and ongoing fragmentation effects that could possibly be managed through changes in Project operations or other measures. The study could, among other things, identify which tributaries, or other isolated reaches, have the greatest potential to respond to management activities. The results of the study will be used as the basis for agreement on in-kind restoration or some other appropriate mitigation. The study report should identify any opportunities for resource enhancement. The Services are particularly interested in information that will help them identify opportunities to restore or enhance species diversity in headwater and tributary streams. If there are obvious disjunct populations that can not be expected to be restored, it would be reasonable to pursue in-kind resource enhancements in other portions of the same watershed.

Some macrohabitat variables, such as temperature, elevation, watershed area, and physiographic province could be used as filters for determining if fragmentation is occurring. This study could focus on determining appropriate protection, mitigation, and enhancement measures, after determining the relative contribution of project dams and reservoirs to the overall aquatic fragmentation. A fragmentation study should identify the ongoing impacts caused by the presence of the dams and reservoirs, as well as quantify impacts (e.g., loss of spawning habitat expressed in river miles).

**This study could be developed in phases, with Phase I work to include literature review; habitat characterization on a macro level; and ranking of tributaries. A draft study plan should be developed and reviewed by the natural resource agencies.**

**9. Peaking Operations**

Explore alternative release schedules which would diminish the affects on riverine resources from peaking operations.

Justification. Peaking operations modify downstream environments by scouring bed sediments, and altering the magnitude, duration, and timing of instream flows. These releases generate rapid changes in velocity, depth, and water chemistry, adversely affecting downstream aquatic species and their habitats. Recruitment of riverine species below dams of peaking operations is low due to the highly variable conditions and the downstream transport of eggs and larvae. Alternatives to current project operations are necessary to determine possible restoration and/or enhancement measures.

**10. Out-migration and Entrainment/Mortality Study**

An evaluation of existing and potential resident and diadromous fish out-migration and entrainment/mortality at each of the project dams is needed to assess project-related factors influencing fish populations in the river basin. Out-migration (spillway and turbine passage) may be significant in terms of recruitment for river basin populations. An understanding of existing and potential out-migration and turbine passage is needed in connection with diadromous fish passage feasibility analyses at the project.

The out-migration study should include the frequency and characteristics of spillway water releases with respect to potential out-migration by target resident and diadromous fish species at the project dams. Limnological studies should be included that document monthly changes in dissolved oxygen, temperature, conductivity, turbidity, thermocline development and overturn under normal hydropower operations. This study element should include ~~multiple years of data to help provide an understanding of limnology and habitat conditions~~ likely to be encountered by outmigrating adult, juvenile, and egg/larval fish life stages at the project dams.

A literature-based study summarizing entrainment mortality studies on similar projects should be conducted. The database on existing entrainment and mortality studies has been greatly enhanced by the Aclass of 93" relicensings. It is conceivable that a sufficient database exists on similar sites with similar turbines from which to draw reasonable conclusions relative to entrainment and mortality in lieu of conducting a site-specific study. The Services are amenable to exploring this possibility of this approach, however, there is a distinct possibility that site-specific studies utilizing recovery netting and appropriately designed mortality studies may be necessary. The top and bottom elevation of the trashracks,

the width of the trashracks, or the clear spacing for all of the trashracks should be described. Also, we need to know mean velocities in front of the intakes across the full range of operating conditions. These are the minimum data needed to determine if fish impingement and entrainment might be a problem at each development. The need for a more complete impingement, entrainment and turbine mortality study should be discussed with the Services, the state natural resource agencies, and other interested parties.

Justification. The cumulative loss of fish from entrainment and mortality at the 11 hydropower developments on the Catawba-Wataree Rivers is of concern. An estimate of these losses at this project is necessary to determine the type and extent of mitigation (avoidance, minimization, compensation) necessary to off-set loss of public trust resources.

#### **11. Bypassed Reach**

Explore and evaluate the feasibility of partial or total removal of the Mountain Island Diversion Spillway, the Great Falls Diversion Dam and/or alternative methods to return instream flows to the Great Falls.

Justification. The Mountain Island Diversion Spillway located downstream of Fishing Creek Dam diverts the Catawba River into a parallel canal and bypasses and dewateres 10,900 linear feet of the Great Falls. The Great Falls Spillway bypasses 3,100 linear feet of river. The Great Falls bypass consists of bedrock, boulders and rocky shoals that if re-watered would provide extremely high quality riffle/shoal habitat for a multitude of species, including spawning habitat for anadromous species. Restoring instream flows to the dewatered Great Falls for fish and invertebrate habitat and passage is a management objective of the Services.

#### **12. Instream Flow Studies**

The Services are concerned about the effects of the project operation on downstream flows in terms of water quantity (timing and delivery) and water quality (dissolved oxygen, pH, temperature, nutrients, suspended solids). We recommend a comprehensive instream flow study of all riverine reaches downstream of the project's developments. The study should utilize standard methods including instream flow incremental methodology, MesoHABSIM, and Indicators of Hydrologic alteration (IHA), to evaluate the project effects on aquatic and riparian communities. The Services are anxious to participate in an interagency team to determine detailed study plans which consider target species and/or habitat guilds, habitat suitability indices, location of study reaches and placement of transects. We further request a detailed study of how water withdrawals, discharges, and non-project uses of project lands and waters affect instream flows, project operation, and fish and wildlife habitats.

The Services recommend a detailed study using MesoHABSIM (Parasiewicz 2001). The design proposed here builds upon the Instream Flow Incremental Methodology but is focused on the need for managing large-scale habitats and river systems like the Catawba-Wataree. It modifies

the data acquisition technique and analytical resolution of standard approaches, changing the scale of physical parameters and biological response assessment from micro- to meso-scale. In terms of technological process, a highly detailed microhabitat survey of a few, short sampling sites is replaced by mesohabitat mapping of whole-river sections. As with more traditional stream habitat models, the variation in the spatial distribution and amount of mesohabitats can provide key information on habitat quality changes that correspond to changes in flow, channel morphology, and potential stream enhancement measures. This methodology should provide a basis for quantifying habitat and simulating potential habitat changes with project operations. Other investigations (e.g., Freeman et al. 2000), used microscale measurements, identified the central role of shallow-water habitat in supporting stream fishes and explained responses of communities to river regulation. Fish-habitat data at the mesoscale is relevant for river management, impact assessment, and fish conservation. The results of analyzing microscale data are most easily presented and used at the mesoscale.

**Indicators of Hydrologic Alteration (IHA)** should be used to describe the operational effects of the project on riverine flows. We expect to utilize IHA analyses to evaluate the effects of project operation on aquatic communities and their habitat. We also expect to identify potential protection, enhancement, and mitigative measures to benefit fish and wildlife resources in the affected reaches.

Freeman, M. C., Z. H. Bowen, K. D. Bovee, and E. R. Irwin. 2000. **Flow and habitat effects on juvenile fish abundance in natural and altered flow regimes. *Ecological Applications* 11:179B190.**

Parasiewicz, Piotr. 2001. MesoHABSIM: a concept for application of instream flow models in river restoration planning. *Fisheries* 26(9)6-13.

Richter, B. D., J. V. Baumgartner, R. Wigington, and D. P. Braun. 1997. How much water does a river need? *Freshwater Biology* 37:231-249.

Stalnaker, C. 1995. The instream flow incremental methodology: a primer for IFIM. National Ecology Research Centre, Internal Publication. U.S. Department of the Interior, National Biological Service, Fort Collins, Colorado.

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### **13. Floodplain Inundation Evaluation**

Assess flows needed for incremental levels of inundation of the Wateree River floodplain. Evaluation should be conducted using the steps outlined in the section on the Floodplain Inundation Method in *Instream Flows for Riverine Resource Stewardship* (2002). This model consists of the following sequential steps:

1. Determine representative floodplain cross-sectional elevations through (a) the Federal Emergency Management Agency (FEMA) and/or the U.S. Army Corps of Engineers (USACOE) flood risk maps; (b) topographic maps; (c) on-site surveys, including aerial

photogrammetric techniques;

2. Determine cross-section/stage-discharge relation by (a) measuring and surveying, (b) gage calibration rating table, or (c) gage records;
3. Determine wetted perimeter versus discharge relation and inflection points for floodplain cross section;
4. Tabulate phenology and inundation needs for floodplain and riparian vegetation and timing of floodplain-dependent life stages of fishes and other floodplain-dependent fauna;
5. Determine historical, unmodified hydrological timing, and magnitude of high flows;
6. Evaluate surface connectivity between main channel and off-channel habitats such as oxbow lakes through review of information obtained in steps 1 and 2 above;
7. Evaluate timing and duration needed to address biological needs tabulated in step 4 and historical hydrology, step 5;
8. Develop flow recommendation or compare alternatives based on review of information from steps 5 to 7.

Justification. Floodplain connectivity is an important ecological function within a river system. Floodplain inundation contributes nutrients and woody debris to the system, provides water cleansing functions, and creates a specialized habitat for floodplain spawners. Reconnection of the river with its floodplain will contribute to a more fully functional ecosystem. The study is needed to obtain the information necessary to evaluate the positive benefits changes in flow patterns may make.

#### 14. Mussel Surveys

Survey the tailwaters of each project development for freshwater mussels to document the distribution, relative abundance, and reproductive success, as well as significant tributaries which are isolated by the project and its operation. Additional, targeted surveys should determine the presence/absence of federally listed mussels and federal species of concern.

Justification. Populations of eight species of freshwater mussel have been documented in the Catawba River. Additional mussel species have been documented in tributaries. The Catawba-Wateree reservoirs impound dozens of miles of mainstem riverine habitat, isolating populations of freshwater mussels and other nongame species in tributaries. Additionally, these reservoirs are close enough to one another to affect much riverine habitat between dams, limiting the recovery gradient in mussel populations in the tailwaters.

#### 15. Robust Redhorse Surveys

The Robust redhorse and A Carolina redhorse are rare sucker species that may occur downstream and/or within the project. These species have been recently (re)discovered through intentional sampling efforts in adjacent basins. Similar directed sampling efforts are needed in suitable habitats for these species in the project reservoirs and large tributaries. A management plan will need to be prepared if these species are found in or upstream of the

project. The applicant should intensively conduct electrofishing surveys for the imperiled robust redhorse and A Carolina redhorse in identified reaches during the spring spawning period and gill net for juveniles and/or adults during the fall months to determine the presence/absence of the species within the project.

Electrofishing should be conducted during daylight hours over gravel bars and shoals when water temperatures range from 18-24E C. The target electrofishing field should be 30-60 pulses per second with the voltage regulated to achieve an electrical output of 3-5 amperes.

Justification. The robust redhorse sucker (*Moxostoma robustum*) once thought extinct was re-discovered in 1991 in the Oconee River, Georgia. Adults and juveniles have recently been collected in the adjacent Yadkin-Pee Dee River drainage basin. The historic range of the robust redhorse included Atlantic Slope drainages from the Pee Dee River in North Carolina to the Altamaha River in Georgia. The Catawba-Watauga basin has never been adequately surveyed for the presence of the robust redhorse. The robust redhorse is considered imperiled and is a Federal Species of Concern. Intensive surveys to determine its presence or absence will aid the Services in determining appropriate flow recommendations for specific reaches and habitat restoration and/or enhancement measures. The Service will also use information from these studies to determine need for and prescriptions of fishways, as well as potential protective status under the Endangered Species Act.

#### 16. Water Quality Studies

The Services goal is to insure that water quality of the reservoirs, bypasses and tailwaters meet all standards set by the States for the designated surface water classification. The Services are also interested in ensuring that project operations do not cause the concentration of toxic and other deleterious substances in fish to rise above State standards, Food and Drug Administration action levels, or U.S. Environmental Protection Agency screening values for the protection of human health. We also want to ensure that project operations such as cleaning of trashracks does not create water quality problems. We are interested in optimizing water quality for selected target species, and want to assist in the design of appropriate mitigation for project impacts. Our mitigation policy follows a stepwise approach that seeks first to avoid, then minimize, and compensation project impacts.

From the fisheries perspective, dissolved oxygen, temperature and turbidity are the parameters of greatest concern. Under certain circumstances, the Services may recommend other limitations to protect listed species or especially valuable resources or fisheries. Water quality information concentrating on dissolved oxygen and temperature in the reservoirs, tailraces, and downstream areas is necessary. Available existing water quality data should be reviewed to determine the need for additional sampling. If additional sampling is necessary, seasonal samples should be taken diurnally (early morning and late afternoons) and should adequately cover the water column.

Basic sampling regimes should be conducted on the reservoir and tailrace under the normal operating conditions. If the development is not currently operating, existing conditions should be measured and the license should include an article requiring data collection after the project is functional. In both cases, more detailed studies may be required upon completion of the first stage. At reservoirs, monthly temperature and dissolved oxygen profiles should be documented at the dam and near the inflow, as well as at regular intervals and in important tributary arms, depending on the size and configuration of the impoundment. Data should be collected during the day at 1-meter intervals from the surface to the bottom. Also, the age, mean depth, maximum depth, surface area, retention time, and trophic state should be summarized for each reservoir.

Continuous (hourly intervals) monitoring of dissolved oxygen, temperature, pH, and turbidity should be conducted at the powerhouse and at 1-mile intervals downstream in the tailraces. Sediment transport rates should be gathered from each station. Concurrent flow measurements should be recorded from USGS gaging stations or calibrated gages installed for the project. Other project specific stations will be designated as agreed by the natural resource agencies. The data collection interval normally will not be continuous for these additional stations.

Justification. Adequate water quality conditions are necessary for the continual existence of aquatic biota. Historically, water quality problems exist within some reservoirs and below reservoirs operating in peaking modes within the project. Several reaches within the project are not fully supporting their designated uses and contain waters that have been listed as Impaired by the South Carolina Department of Health and Environmental Control, or the North Carolina Division of Water Quality.

**17. Shoreline Habitat and Littoral Enhancement**

A detailed study of current shoreline and littoral habitat should be conducted. Existing aquatic habitat should be mapped in the drawdown zones of reservoirs and the littoral zones for inclusion in a GIS-based database. An analysis should then be conducted to evaluate the impacts of fluctuating water levels under existing Project operations on the existing fishery and aquatic habitats in the impoundments, as well as to characterize the recent and near-term losses of these habitats to non-project uses of lands within the project boundary.

Habitat mapping should include mapping of significant aquatic habitat in the drawdown and the littoral zones of reservoirs during the fall/early winter using a GPS unit coupled with a laser, digital movie camera, laptop computer and appropriate software. The laser scope will enable a crew to pinpoint and outline important habitat features from a boat (sub-meter accuracy) to calculate habitat area. Habitat types will include, but not be limited to stream confluences, aquatic vegetation, woody debris (natural and cut), structures (piers, docks, marinas, etc.), rock habitat (gravel, cobble, boulder and ledge), and sand/clay habitat. Because drawdowns are minimal in some reservoirs, detailed mapping there can be limited to exposed shoreline substrates and other observable habitat features, such as aquatic vegetation, lap trees, and rock outcroppings. Habitat data should be imported into an ARC View data file so the amount of aquatic habitat (acres and ft<sup>2</sup>) can be calculated. During the habitat surveys,

the entire shoreline of all reservoirs should be filmed with a digital movie camera connected to the GPS unit. Areas of significant erosion should also be located (lat/lon) and filmed during this survey. Significant wetlands (water willow, etc.) should be noted. **Docks and piers, should be located with GPS, and included as a data layer in the GIS system. Reservoir fluctuation should be evaluated by looking at effects of the current Project operations and water level fluctuations on existing fishery and aquatic habitats, including impacts to fish species of management concern during the spawning season and impacts due to daily and seasonal drawdowns. Fish species evaluated should include those that spawn in the littoral zone, such as largemouth bass, and sunfish species (bluegill, pumpkinseed etc). Other fish, such as forage species that are pelagic spawners (threadfin and gizzard shad, blueback herring) should also be evaluated. The habitat surveys discussed above will be used to quantify impacts of fluctuations on fish and aquatic habitats. Alternative reservoir operations should be considered to reduce drawdown zones, and or limit seasonal changes (fill reservoir sooner or hold full longer, etc.).**

Justification. The results of this evaluation will be used to assess impacts of reservoir operations and fluctuations on fish and wildlife habitat, as well as to determine potential changes to mitigate any impacts.

18. **Endangered Species**

The ICD lists a few rare, threatened and endangered species within the project boundary, but it does not list all of those species that actually occur within or adjacent to the project boundary, nor those which may be affected by project operations. For example, the American bald eagle nests at several developments within the project, using project waters as foraging and roosting habitat, yet most known nests are just outside the project boundary. This species should be considered in surveys for nests, as well as potential nesting habitat. In addition, bats may occur in the project areas, particularly in the powerhouses, dams and other structures. Directed sampling efforts are needed to document all listed species occurrences of all listed species in order to determine the potential impact of the project on their populations.

Enclosed is a list of species from Alexander, Burke, Caldwell, Catawba, Gaston, Iredell, Lincoln, McDowell, and Mecklenburg counties in North Carolina, and Chester, Fairfield, Kershaw, Lancaster, and York counties in South Carolina, that are on the *Federal List of Endangered and Threatened Wildlife and Plants* or constitutes species of Federal concern that may occur in the project impact area. We recommend surveying the project area for these species prior to any further planning. We do have records from the project area of the endangered Schweinitz=s sunflower (*Helianthus schweinitzii*) and Heller=s trefoil (*Lotus helleri*), a species of Federal concern. The Services recognize that species of Federal concern are not legally protected under the Act and are not subject to any of its provisions, including Section 7, unless they are formally proposed or listed as endangered or threatened. We are including these species in our response to give you advance notification. The presence or absence of these species in the project boundary and the area of effect of the project operation should be addressed in any environmental document prepared for this project.

Carolina heelsplitter (*Lasmigona decorata*). There are records of the Carolina heelsplitter from the Catawba River in the vicinity of the project. A targeted survey should be conducted for the Carolina heelsplitter to include selected tributaries to the Catawba River within and adjacent to the project boundary. The Service, along with Duke Power, Entrixx, and others performed a reconnaissance-level survey on October 26, 2001 of a limited area immediately below the Lake Wylie dam along the right bank (Catawba River, right channel thread at Fewell Island, immediately below Lake Wylie dam. 35.0167N, 81.0037W). The following were located:

*Strophitis undulatas* - creeper

*Elliptio complanata* - eastern elliptio

*Elliptio producta/angustata* - Atlantic spike/Carolina lance

*Pyganodon cataracta* - eastern floater

*Utterbackia imbecillis* - paper pondshell

*Villosa delumbis* - eastern creekshell

*Corbicula fluminea* - Asiatic clam

At the I-77 bridge Catawba River (main channel, and upstream 300 yards; 34.9876N, 80.9854W) we located:

*Elliptio complanata* - eastern elliptio

*Elliptio producta/angustata* - Atlantic spike/Carolina lance

At Landsford Canal State Park, (34.8211N, 80.8823W), the water was too turbid, and though we mostly looked for middens, no native mussels found, only *Corbicula fluminea* (Asiatic clam). There was an abundance of the non-native *Corbicula* at all sites, unfortunately. We did not adequately survey for the presence/absence of the Carolina heelsplitter in the area of affect of the project. At the time of the survey, we notified Duke Power and Entrixx staff that there was a fairly diverse mussel assemblage at the site just below the Wylie powerhouse, and that this site, along with other reaches, bears further looking.

Schweinitz=s sunflower (*Helianthus schweinitzii*). The Schweinitz=s sunflower does occur within the area of affect of the Project, including within the project boundary. Additional surveys should be conducted for this species, so that species protection plans may be developed for all occurrences at the project.

Georgia aster (*Aster georgianus*). The Georgia aster is a candidate species, and it does occur within the area of affect of the action. Therefore, we recommend studies to include information about this species, and how it may be affected by the continued operation of the project, and any modifications made to the project operation of facilities during the next license. We expect that FERC will need this information to complete a conference with the Service for this species. We expect to use this information to determine the protective needs of the species pursuant to the Endangered Species Act.

Robust Redhorse (*Moxostoma robustum*) and ACarolina= Redhorse (*Moxostoma* sp1). Although DeWitt (1998) used a variety of sampling gear and documented a significant diversity of fishes from the Catawba River downstream of Lake Wylie, the methodologies employed were not adequate to detect the robust redhorse or Carolina redhorse, large mobile fishes. We are quite concerned about how the project operation and project works affect these rare fishes. We expect to use this information to determine mitigative measures for

operation of the project, as well as for determining the protective needs of the species pursuant to the Endangered Species Act.

Shortnose sturgeon (*Acipenser brevirostrum*). Intensive surveys to determine its presence or absence will aid the Service in determining appropriate flow recommendations for specific reaches and habitat restoration and/or enhancement measures. The Service will also use information from these studies to determine need for and prescriptions of fish ways.

Rocky shoals spider lily (*Hymenocallis coronaria*). We recommend targeted surveys for this species, to identify the range and habitats, including collection of data which may describe how the project operation affects the species. We expect to use this information to determine mitigative measures for operation of the project, as well as for determining the protective needs of the species pursuant to the Endangered Species Act.

We recommend that surveys be conducted by comparing the habitat requirements for these species with available habitat types within the action area of the project. AAction area≡ is defined at 50 CFR § 402.02 as A...all areas to be affected directly or indirectly by the Federal action and not merely the immediate area involved in the action.≡ Field surveys for the species should be performed if habitat requirements overlap with that available at the project site. Surveys for protected plant species must be conducted by a qualified biologist during the flowering or fruiting period(s) of the species. We welcome the opportunity to assist with the design of studies, sampling schemes, methodology, and target areas for the above species, as well as analysis of the Aeffects fo the action,≡ (as defined by 50 CFR § 402.02) on any listed species including consideration of direct, indirect, and cumulative effects.

We also recommend contacting the S.C. Department of Natural Resources (SCDNR), Data Manager, Wildlife Diversity Section, Columbia, S.C. 29202 concerning known populations of federal and/or state endangered or threatened species, and other sensitive species in the project area. Additional habitat information may also be available from SCDNR. NOAA Fisheries endangered species office in St. Petersburg, Florida should be contacted relative to shortnose sturgeon which may occur in the action area.

#### **15. Migratory Birds**

Evaluate the effects of the project on migratory bird use of the Catawba-Wateree riverine and riparian ecosystems. Surveys of migratory birds and their habitats should begin in the Fall of 2003 to provide baseline information on populations.

Justification. Migratory birds, particularly neotropical migrants, utilize the Catawba-Wateree system for wintering habitat. These species have potentially been adversely affected by the project by the decrease in available wetlands and floodplain habitat, loss of foraging habitat, and alteration of riparian habitat. Information on population estimates and habitat utilization are needed to determine potential enhancement measures.

#### **16. Project Operations**

Evaluate the effects of project operations on ecological processes, including geomorphic functions, sediment regime, and woody debris cycling in riverine reaches. This study should assess the effects of project operations and project works on distribution and flow of sediments, woody debris, and nutrients through the project.

Justification. Project developments (dams) impede the natural flow of sediment, woody debris, and nutrients through the river system. The alteration of natural geomorphic

processes adversely affects downstream aquatic flora and fauna by limiting the elements necessary for species to adequately complete their life cycles. An evaluation of these effects will aid in the development of restoration, enhancement and mitigation measures.

#### **17. Potential Mitigation Options**

While the relicensing of the Catawba-Wateree Project has just begun, it is not too early to begin investigating off-site and non-traditional mitigation opportunities. Small, non-functional dams within the basin that could be removed should be identified. Elimination of these barriers would help to restore riverine ecology to these systems. Another possibility is conducting stream and wetland restoration projects or purchasing riparian easements in the basin. Conservation efforts, such as the acquisition, protection, and establishment of wide forested riparian buffers, should focus on tributaries identified as supporting freshwater mussels and other rare species, or tributaries identified as priority aquatic habitats. The applicant should identify areas that could be protected or enhanced for migratory birds. The Services are also concerned about the adequate provision of opportunities for fish- and wildlife-based recreation, such as bird watching, fishing and hunting. There may be opportunities for Duke Power to enhance the project area for these activities. **We request a map of other Duke Power and other Duke Energy properties to assess the juxtaposition of these lands to important wildlife areas.**

**If you have any questions about these study recommendations, or need additional information, please contact Mr. Mark A. Cantrell, at (828) 258-3939 (ext. 227), or Ms. Amanda Hill, at (843) 727-4707 (ext. 24) of the U.S. Fish and Wildlife Service and Mr. Prescott Brownell, at (843) 762-8591 of NOAA Fisheries.**

Sincerely,

Roger L. Banks  
Field Supervisor  
U.S. Fish and Wildlife Service

---

David H. Rackley  
Chief, Charleston Area Office  
Habitat Conservation Division  
NOAA Fisheries

**Attachment A. ENDANGERED, THREATENED, AND CANDIDATE SPECIES AND  
FEDERAL SPECIES OF CONCERN, IN THE VICINITY OF CATAWBA-WATEREE  
PROJECT, IN NORTH CAROLINA AND SOUTH CAROLINA**

This is a listing of federally listed and proposed endangered, threatened, and candidate species and Federal species of concern (for a complete list of rare species in each state, please contact the North Carolina Natural Heritage Program or the South Carolina Natural Heritage Program). The information in this list is compiled from a variety of sources, including field surveys, museums and herbaria, literature, and personal communications. Our database is dynamic, with new records being added and old records being revised as new information is received. Please note that this list cannot be considered a definitive record of listed species and Federal species of concern, and it should not be considered a substitute for field surveys.

This list should be used only as a guideline, not as the final authority. The list includes known occurrences and areas where the species has a high possibility of occurring. Records are updated regularly and subsequent versions may be different from the following:

COMMON NAME	SCIENTIFIC NAME	STATUS
"Carolina" madtom	<i>Noturus furiosus</i> population 2	FSC
A liverwort	<i>Cephaloziella obtusilobula</i>	FSC*
A liverwort	<i>Plagiochila sullivanii</i> var. <i>spinigera</i>	FSC
A liverwort	<i>Plagiochila sullivanii</i> var. <i>sullivanii</i>	FSC
A liverwort	<i>Porella wataugensis</i>	FSC*
Alleghany woodrat	<i>Neotoma magister</i>	FSC*
American alligator	<i>Alligator mississippiensis</i>	T(S/A)
American kestrel	<i>Falco sparverius</i>	FSC
Atlantic pigtoe	<i>Fusconaia masoni</i>	FSC
Auriculate false foxglove	<i>Tomanthera auriculata</i>	FSC
Bachman's sparrow	<i>Aimophia aestivalis</i>	FSC
Bald eagle	<i>Haliaeetus leucocephalus</i>	Threatened
Bennett's Mill Cave water slater	<i>Caecidotea carolinensis</i>	FSC
Bent avens	<i>Geum geniculatum</i>	FSC
Biltmore greenbriar	<i>Smilax biltmoreana</i>	FSC
Black-spored quillwort	<i>Isoetes melanospora</i>	FSC
Bog turtle	<i>Clemmys muhlenbergii</i>	T(S/A)1
Brook-floater	<i>Alasmidonta varicosa</i>	FSC
Buttercup phacelia	<i>Phacelia covillei</i>	FSC
Butternut	<i>Juglans cinerea</i>	FSC
Carolina bogmint	<i>Macbridea caroliniana</i>	FSC
Carolina creekshell	<i>Villosa vaughaniana</i>	FSC
Carolina darter	<i>Etheostoma collis collis</i>	FSC
Carolina heelsplitter	<i>Lasmigona decorata</i>	Endangered
"Carolina" redhorse	<i>Moxostoma</i> sp1	FSC
Carolina pygmy sunfish	<i>Elassoma boehlkei</i>	FSC
Carolina saxifrage	<i>Saxifraga caroliniana</i>	FSC
Catawba crayfish ostracod	<i>Dactyloctenya isabelae</i>	FSC
Cerulean warbler	<i>Dendroica cerulea</i>	FSC
Creeping St. John's Wort	<i>Hypericum adpressum</i>	FSC
Cuthbert's turtlehead	<i>Chelone cuthbertii</i>	FSC

Diana fritillary butterfly	<i>Speyeria diana</i>	FSC
Georgia aster	<i>Aster georgianus</i>	Candidate
Dwarf-flowered heartleaf	<i>Hexastylis naniflora</i>	Threatened
Edmund's snaketail dragonfly	<i>Ophiogomphus edmundo</i>	FSC
Fraser fir	<i>Abies fraseri</i>	FSC
Georgia aster	<i>Aster georgianus</i>	C1
Gray's lily	<i>Lilium grayi</i>	FSC
Heller's blazing star	<i>Liatris helleri</i>	Threatened
Heller's trefoil	<i>Lotus helleri</i>	FSC
Henslow's sparrow	<i>Ammodramus henslowii</i>	FSC
Little amphianthus	<i>Amphianthus pusillus</i>	Threatened
Loggerhead strike	<i>Lanius ludovicianus</i>	FSC
Margarita River skimmer	<i>Macromia margarita</i>	FSC*
Michaux's sumac	<i>Rhus michauxii</i>	Endangered*
Mountain bittercress	<i>Cardamine clematitis</i>	FSC
Mountain golden heather,	<i>Hudsonia montana</i>	Critical Habitat
Northern oconee-bells	<i>Shortia galacifolia</i> var. <i>brevistyla</i>	FSC
Olive-sided flycatcher	<i>Contopus borealis</i>	FSC
One-flower stitchwort	<i>Inuartia uniflora</i>	FSC
Painted bunting	<i>Passerina ciris ciris</i>	FSC
Pee Dee crayfish ostracod	<i>Dactylocythere peedeensis</i>	FSC*
Pinewoods shiner	<i>Lythrurus matutinus</i>	FSC
Pondspice	<i>Litsea aestivalis</i>	FSC
Prairie birdsfoot-trefoil	<i>Lotus purshianus</i> var. <i>helleri</i>	FSC
Pygmy snaketail dragonfly	<i>Ophiogomphus howei</i>	FSC
Rafinesque's big-eared bat	<i>Corynorhinus rafinesquii</i>	FSC
Red-cockaded woodpecker	<i>Picoides borealis</i>	Endangered
Riparian vervain	<i>Verbena riparia</i>	FSC*
Roan sedge	<i>Carex roanensis</i>	FSC
Robust redhorse	<i>Moxostoma robustum</i>	FSC
Rocky Shoals spider-lily	<i>Hymenocallis coronaria</i>	FSC
Sandhills milkvetch	<i>Astragalus michauxii</i>	FSC
Savanna lilliput	<i>Toxolasma pullus</i>	FSC
Schweinitz's sunflower	<i>Helianthus schweinitzii</i>	Endangered
Small whorled pogonia	<i>Isotria medeoloides</i>	Threatened
Smooth coneflower	<i>Echinacea laevigata</i>	Endangered
Southern Appalachian black-capped chickadee	<i>Poecile atricapillus praticus</i>	FSC
Southern Appalachian red crossbill	<i>Loxia curvirostra</i>	FSC
Southern Appalachian saw-whet owl	<i>Aegolius acadicus</i>	FSC
Southern Appalachian woodrat	<i>Neotoma floridana haematoreia</i>	FSC*
Southern Appalachian yellow-bellied sapsucker	<i>Sphyrapicus varius appalaciensis</i>	FSC
Southern dusky salamander	<i>Desmognathus auriculatus</i>	FSC
Southern myotis	<i>Myotis austroriparius</i>	FSC
Spreading avens	<i>Geum radiatum</i>	Endangered
Spruce-fir moss spider	<i>Microhexura montivaga</i>	Endangered
Sun-facing coneflower	<i>Rudbeckia heliopsidis</i>	FSC
Swainson's warbler	<i>Limnothlypis swainsonii</i>	FSC
Sweet-pinesap	<i>Monotropsis odorata</i>	FSC*

Tall larkspur	<i>Delphinium exaltatum</i>	FSC*
Virginia least trillium	<i>Trillium pusillum</i> var. <i>virginianum</i>	FSC
Virginia quillwort	<i>Isoetes virginica</i>	FSC
White false asphodel	<i>Tofieldia glabra</i>	FSC
White-wicky	<i>Kalmia cuneata</i>	FSC
Wire-leaved dropseed	<i>Sporobolus teretifolius</i>	FSC
Yellow lampmussel	<i>Lampsilis cariosa</i>	FSC
Yellow lance	<i>Elliptio lanceolata</i>	FSC

#### KEY:

Status	Definition
Endangered	A taxon "in danger of extinction throughout all or a significant portion of its range."
Threatened	A taxon "likely to become endangered within the foreseeable future throughout all or a significant portion of its range."
Proposed	A taxon proposed for official listing as endangered or threatened.
C1	A taxon under consideration for official listing for which there is sufficient information to support listing.
FSC	A Federal species of concern--a species that may or may not be listed in the future (formerly C2 candidate species or species under consideration for listing for which there is insufficient information to support listing).
T(S/A)	Threatened due to similarity of appearance (e.g., American alligator)--a species that is threatened due to similarity of appearance with other rare species and is listed for its protection. These species are not biologically endangered or threatened and are not subject to Section 7 consultation.
EXP	A taxon that is listed as experimental (either essential or nonessential). Experimental, nonessential endangered species (e.g., red wolf) are treated as threatened on public land, for consultation purposes, and as species proposed for listing on private land.

Species with 1, 2, 3, or 4 asterisks behind them indicate historic, obscure, or incidental records.

\*Historic record - the species was last observed in the county more than 50 years ago.

\*\*Obscure record - the date and/or location of observation is uncertain.

\*\*\*Incidental/migrant record - the species was observed outside of its normal range or habitat.

\*\*\*\*Historic record - obscure and incidental record.

#Contact NOAA Fisheries for more information on this species.



# Letter 19

RECEIVED 11 22 2004

**Duke Power**  
526 South Church Street  
P.O. Box 1006  
Charlotte, NC 28201-1006

Mail Code EC12Y

November 19, 2004

Mr. Richard Sidebottom  
South Carolina Department of Archives & History  
8301 Parklane Rd  
Columbia, SC 29223

Subject: Catawba-Wateree Hydroelectric Project (FERC #2232)  
Draft Survey Report

Dear Mr. Sidebottom:

Enclosed please find 2 copies of a document titled "*Cultural Resources Survey for the Catawba-Wateree Hydroelectric Project, Chester, Fairfield, Kershaw, Lancaster and York Counties, South Carolina, FERC Project No. 2232, Revised Draft Report.*" This report was prepared by TRC Garrow as outlined in the Catawba-Wateree Relicensing Project Study Plan Cultural 01.

Please provide any comments you have on the report by December 29, 2004.

Please do not hesitate to contact me at 980.373.4392 or [jrhuff@duke-energy.com](mailto:jrhuff@duke-energy.com) should you have any questions regarding the relicensing effort or this document.

Thank you for your continued participation in the relicensing process.

Sincerely:

Jennifer Huff  
Hydro Licensing & Compliance

Enclosure (2 copies)

cc w/o enclosure: Chad Long, South Carolina Department Archives & History  
Bill Green, TRC  
Mark Oakley

**Huff, Jennifer R**

---

**From:** "Long, Chad" <LONG@scdah.state.sc.us>@PEC  
**Sent:** Tuesday, June 27, 2006 3:36 PM  
**To:** Huff, Jennifer R  
**Cc:** Dobrasko, Rebekah  
**Subject:** CW HPMP

Dear Jen,

Thank you for addressing our comments on the revised Historic Properties Management Plan for the Catawba Wateree Hydroelectric Project. The final draft of the HPMP is acceptable.

Regards,

Chad C. Long  
Archaeologist/GIS Manager  
SC State Historic Preservation Office  
8301 Parklane Road  
Columbia, SC 29223  
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8/11/2006